AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

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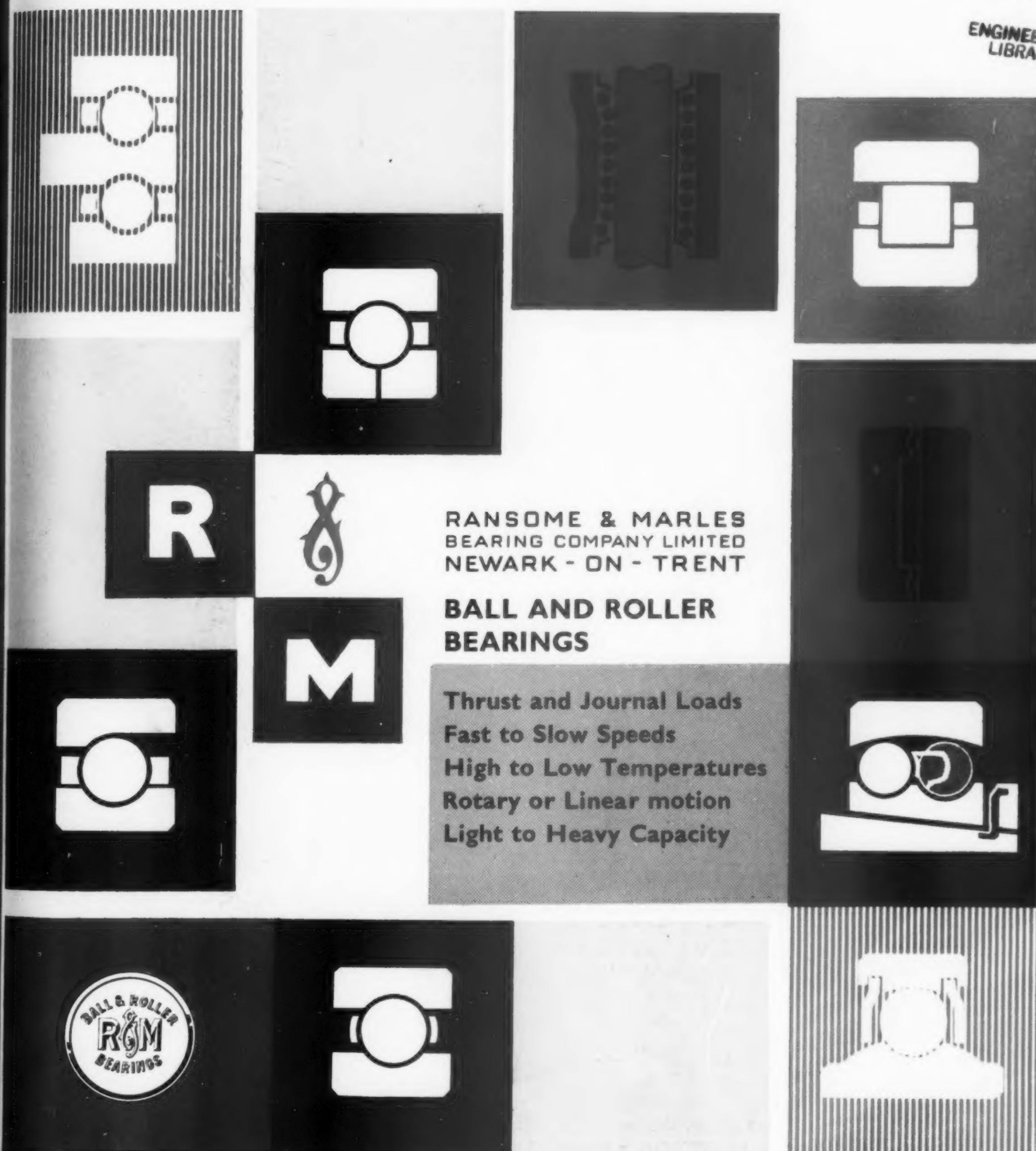

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AUTOMOBILE ENGINEER

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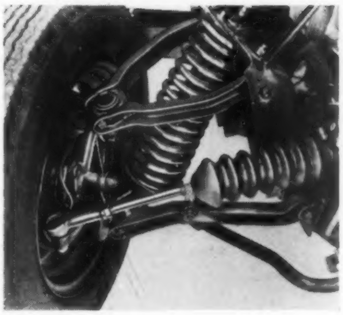

THERE ARE NO LUBRICATION POINTS ON THE TRIUMPH HERALD, THE FRONT SUSPENSION OF WHICH IS SHOWN IN THIS ILLUSTRATION

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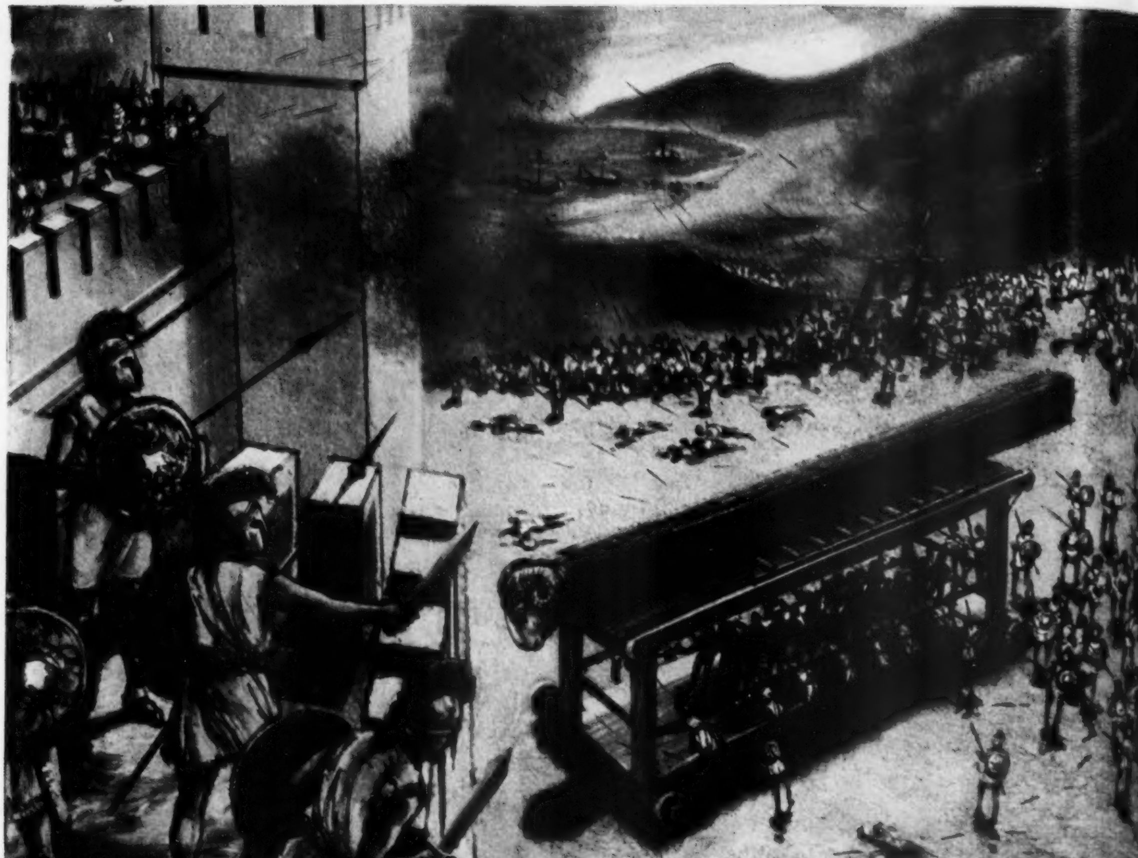
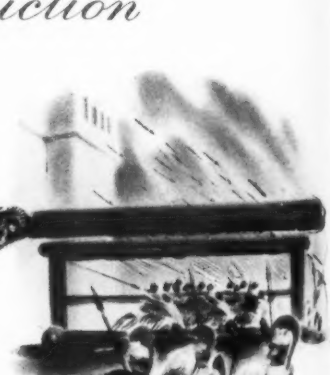


The Conquest of Friction



About 330 B.C. a Greek military engineer, Diades, invented a new form of battering ram, moving on rollers in grooved tracks. The novelty lay in the use of a spacing device or 'cage' for the rollers and the attachment of the ropes, not to the ram itself, but to the cage. By this device the ram was given a motion twice as fast as the restricted pull on the ropes, and moved forward with great speed at the moment of impact.

Diades' wooden battering ram bears little relation to the engines of modern warfare like the tank or the high-speed jet aircraft. To these, as in the development of machines for more peaceful purposes, the resources and manufacturing skill of the SKF organisation have made a major contribution.

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DESIGN MATERIALS **AUTOMOBILE ENGINEER** PRODUCTION METHODS WORKS EQUIPMENT

Graduate and Post-Graduate Training

FOR many years the automobile industry has been faced with a difficult problem arising from the ever-increasing breadth and depth of knowledge needed by its engineering staffs. Further progress at a rate adequate to meet competition can now be made rapidly only by specialization of individual engineers in narrow fields. However, there has been a reluctance to pursue such a policy of specialization because it has been thought that it would restrict the outlook of engineers and, in the long run, this would tend once more to put a brake on progress.

Against this background it has been widely felt that the training of engineering graduates should be aimed at imparting a knowledge of basic principles, leaving the individuals to apply that learning and to develop it in more specialized fields when they have left the educational establishments and are in industry. While this approach is probably satisfactory for some industries, motor vehicle design presents a multitude of complex problems over such a very wide field that graduates plunged into the business without a comprehensive understanding of, for example, steering, stability, suspension and transmission problems are often completely out of their depth. Although their grasp of the fundamental principles of statics and dynamics is, in fact, adequate for dealing with these problems, the graduates are liable to fail because, owing to inadequate specialized knowledge, they are unable to take all the relevant factors into account. The result is that engineers brought up in the old school, who have turned to the university-trained graduates for the solution of their problems, go back in despair to their intuitive and rule-of-thumb methods that are based on past practice and generally, therefore, are not a satisfactory basis for progress.

The alternative is to train the graduates in specialized fields and leave them to broaden the scope of their learning after they have entered industry. At first sight it appears completely unreasonable to expect the educational establishments, rather than the industry, to teach automobile engineering. However, there is some sense in this proposition, and the only ground for controversy is the extent to which specialization should be carried in graduate training. The advantage to the industry would be that it would receive a flow of well-trained automobile engineers, as distinct from well-trained general engineers. Of these, a large number would not have the drive and initiative to develop themselves further, and, therefore, they would simply make normal progress, as they gained experience in their chosen special fields. But there would also be those who would broaden their knowledge and who had the qualities necessary for more rapid advancement to the higher executive positions.

In fact, this idea in principle is not new. The aircraft industry, since the war, has been able to draw on the resources of a college devoted solely to the post-graduate training of aeronautical engineers to a very high standard, and there are also chairs of aeronautical engineering at a number of the universities. As a result, during a relatively short period of time, the advances that have been made in this field are vast. Although the rapidity of these advances is due primarily to the application of financial resources on a national scale, it would not have been possible without engineers trained to a very high standard.

Obviously, better graduate and post-graduate training facilities are urgently required for the automobile industry, and it is equally obvious that the initiative will have to come from the industry. It is suggested that two positive steps should be taken. One is that the universities should be approached and the funds provided to found chairs of automobile engineering, such as already exist in some other countries. The second is that a truly national college of automobile engineering should be established for professional training to the requisite high standard.

The reason why both steps should be taken together is that the outcome, in time, would be a number of educational establishments, with both wide and differing fields of experience, competing to turn out the best automobile engineers. It would also result in the development simultaneously of methods of training along different lines, which could not happen with only a single automobile engineering training establishment controlled by one governing body. Individual firms in the industry, by drawing recruits from these different establishments, and also from among graduates trained on traditional lines in general engineering, would then be able to build up balanced teams of individuals who would have a lot to offer each other with regard to the pooling of knowledge and experience. In that way, firms could obtain coverage in respect of not only depth but also breadth of knowledge.

Bristol-E.C.W. Lodekka

Evolution of an Original and Practical Bus Chassis, and Description of Some of the Major Components Employed in its Construction

The low overall height of the Lodekka buses is revealed by this view of a 30 × 8 ft Flat Floor model

SINCE the Transport Act of 1947 came into effect, the position of Bristol Commercial Vehicles Ltd. and Eastern Coach Works Ltd. has been unique, owing to the fact that the Act precluded them from continuing the sale of their chassis and bodies abroad. Moreover, their home market was restricted to organizations controlled by the British Transport Commission. In the case of buses, the sales have, therefore, been limited to the Tilling and Scottish Omnibus groups. Nevertheless, the highly interesting and successful Bristol-E.C.W. Lodekka vehicle, which is a combined production of the two manufacturing firms and was introduced in 1949, received considerable attention from operators outside the groups mentioned.

In spite of its considerable merit, the Lodekka might still not have been available to outside operators but for an agreement that was concluded in 1956 between Bristol Commercial Vehicles and Dennis Brothers Ltd., of Guildford. This agreement allowed the Lodekka to be manufactured under licence by Dennis Brothers and made available to operators in general. The outcome of this arrangement was the Dennis Loline bus, first exhibited in rear entrance form at the Commercial Vehicle Show at Earls Court in 1956. At the 1958 Show, another Dennis Loline was exhibited, this time with a forward, two-step entrance; both these vehicles embodied the Bristol Lodekka chassis design.

As the name implies, the object of that design was the provision of a vehicle of low overall height; it was also desired to embody normal seating and a central gangway on both upper and lower saloons. Because of this unusual combination, the background facts that led up to the inception of the Lodekka layout are of interest. During the war and early thereafter, many provincial bus routes run by companies in the Tilling group were converted from single-deck to double-deck operation, in order to economize on vehicles or to cope with the increased passenger loads. Because of the local conditions, the conversion of many of the routes was only possible through the use of the so-called low-bridge type of body, which incorporates four-abreast seating on the upper deck, with a sunken, off-side gangway.

At that time, the standard double-deck bus used by the Tilling group was the Bristol K type, of entirely orthodox design. Although, for obvious reasons, the low-bridge layout was not much liked either by passengers or operators, its advantages were such that nearly 80 per cent of the K type buses produced for Tilling in 1946 were of that design. The objections to the low-bridge body influenced the Bristol technicians to investigate the possibility of producing a bus in which better characteristics could be obtained.

With the full co-operation of the coachbuilders, Eastern Coach Works, the first prototype Lodekka appeared in 1949. Two examples were built and are still giving satisfactory service today in the Bristol area. To enable the necessary reduction in lower-deck floor height to be obtained, the normal body bearers were eliminated, and the floor was mounted directly on top of the chassis frame structure. The outrigger supports of the body were, in effect, extensions of the frame cross members, and were bolted to the side members. These supports sloped downward towards the middle of the vehicle, and the slope was continued in the upper faces of the cross members for about a quarter of their span. The middle half-span, forming the gangway, was at an appreciably lower level than the extremities. By this means, the height of the gangway from the ground was reduced to 16$\frac{5}{8}$ in, in comparison with the 2 ft 4$\frac{1}{2}$ in of the standard high-bridge and low-bridge buses. Without any reduction of headroom, it was thus possible to keep the

overall laden height to the same figure, 13 ft 2 in, as that of the low-bridge design, this being 1 ft less than the height of the high-bridge buses.

An outline drawing of the prototype chassis is reproduced in one of the accompanying illustrations. The low gangway clearly made an orthodox transmission layout impracticable, so a divided system was evolved. From the offset output shaft on the gearbox, a propeller shaft ran rearward, closely alongside the off-side member of the chassis frame, to a differential and cross-drive unit some distance ahead of the rear wheels. At each end of the cross-drive unit, bevel gears conveyed the drive to individual second-stage propeller shafts. These shafts were coupled to separate worm reduction units, each of which drove one pair of rear wheels only; the units were connected to each other by a substantial beam, downswept in the middle to provide clearance under the gangway.

Modifications for production

The trials and initial service experience of the two prototypes were highly encouraging, so a full development programme was put in hand. In March, 1953, the first production models, considerably altered and improved, went into service. By modifications to the frame cross members and body outrigger support brackets, the lower gangway width was increased, and the inward slope of the floor on each side of the gangway was eliminated.

An important change was made to the transmission: the intermediate differential and cross-drive unit and the separate worm drives were abandoned in favour of the double-reduction design that has been employed ever since. In this later scheme, a single, divided propeller shaft runs from the gearbox to a gear case at the off-side end of the rear axle. The shaft embodies a torsional vibration damper and drives a spiral-bevel primary reduction, which embodies a differential in the orthodox manner. Also within the gear case is a secondary reduction, with straight-tooth spur gears; the input gear of the secondary reduction is mounted directly on the splined, right-hand output shaft of the differential. The left-hand output shaft is splined internally to take one end of a cross shaft. This shaft is enclosed by a hollow axle beam, of square section and downswept in the middle for clearance under the gangway. To the other end of the axle beam is bolted the casing that houses the left-hand secondary reduction; this is of a design almost identical with that of its counterpart on the right-hand side, and its input gear is

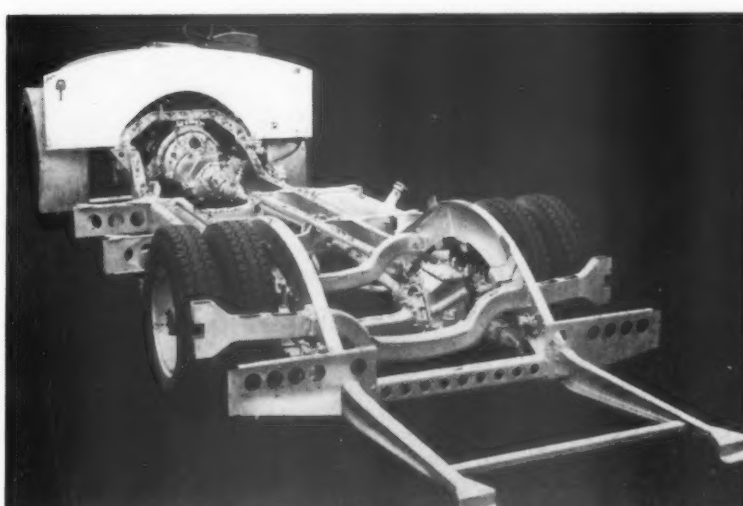
The platform of the rear entrance vehicles has a slight ramp to the gangway level of the bottom saloon

fitted to the other end of the cross shaft, also by splines.

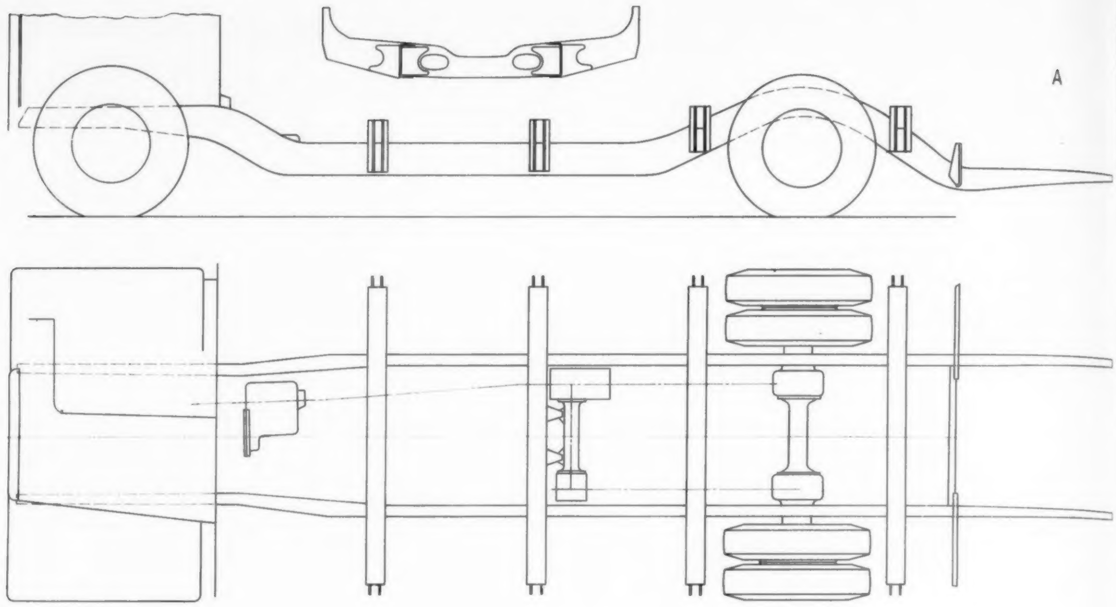
The output shafts of the secondary reductions drive the rear wheels and are of the fully floating type. Their axes lie vertically above those of their respective input shafts, and the gear cases are sufficiently narrow to be accommodated beneath the steps of the longitudinal rear seats of the lower saloon, thereby avoiding any obstruction of the gangway. By variations in the secondary reductions, overall top gear ratios of 5·04 : 1, 5·5 : 1 or 6·0 : 1 are provided.

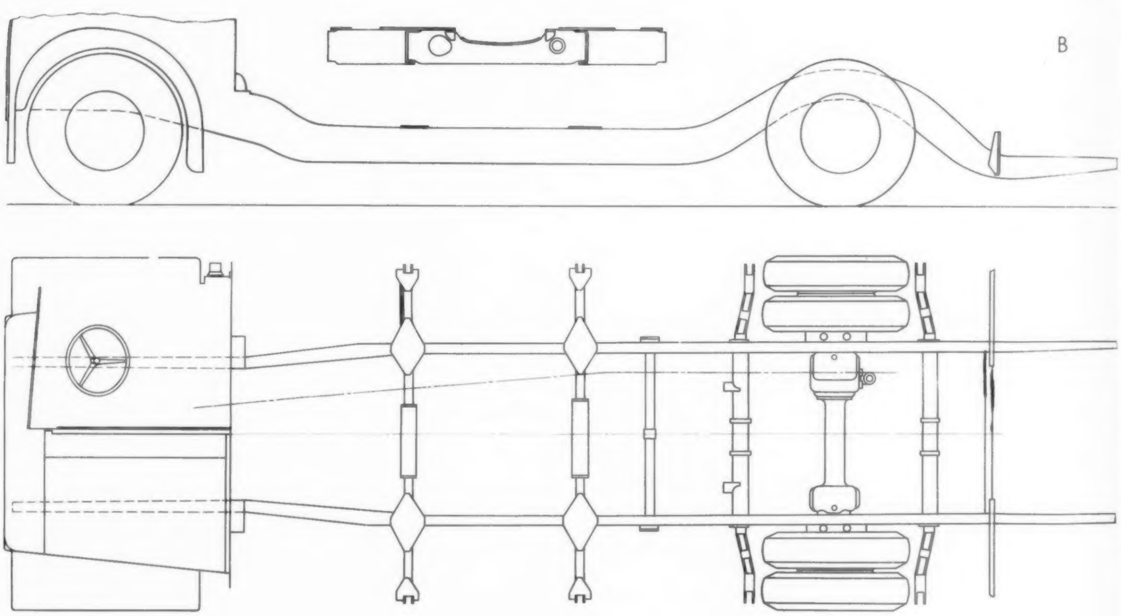
Robust design characterizes the complete axle unit, a sectional view of which is shown in an illustration. Among the interesting detail features are: the use of a thrust bearing, in conjunction with two roller bearings, for the location of each wheel hub; the extensive employment elsewhere of roller bearings with single-lipped outer races; and the double needle-roller bearing to carry the right-hand output shaft in the differential casing. On earlier axles of this type, coarse splines of rectangular section were used on the differential and wheel shafts, but these have been replaced by finer splines of involute tooth form.

This production Lodekka design amply fulfilled the promise of the prototypes, and such was its success that



This illustration of the standard Lodekka chassis shows the offset propeller shaft line, the dipped cross members of the frame, and the extensions of the side members behind the wheels to carry the platform



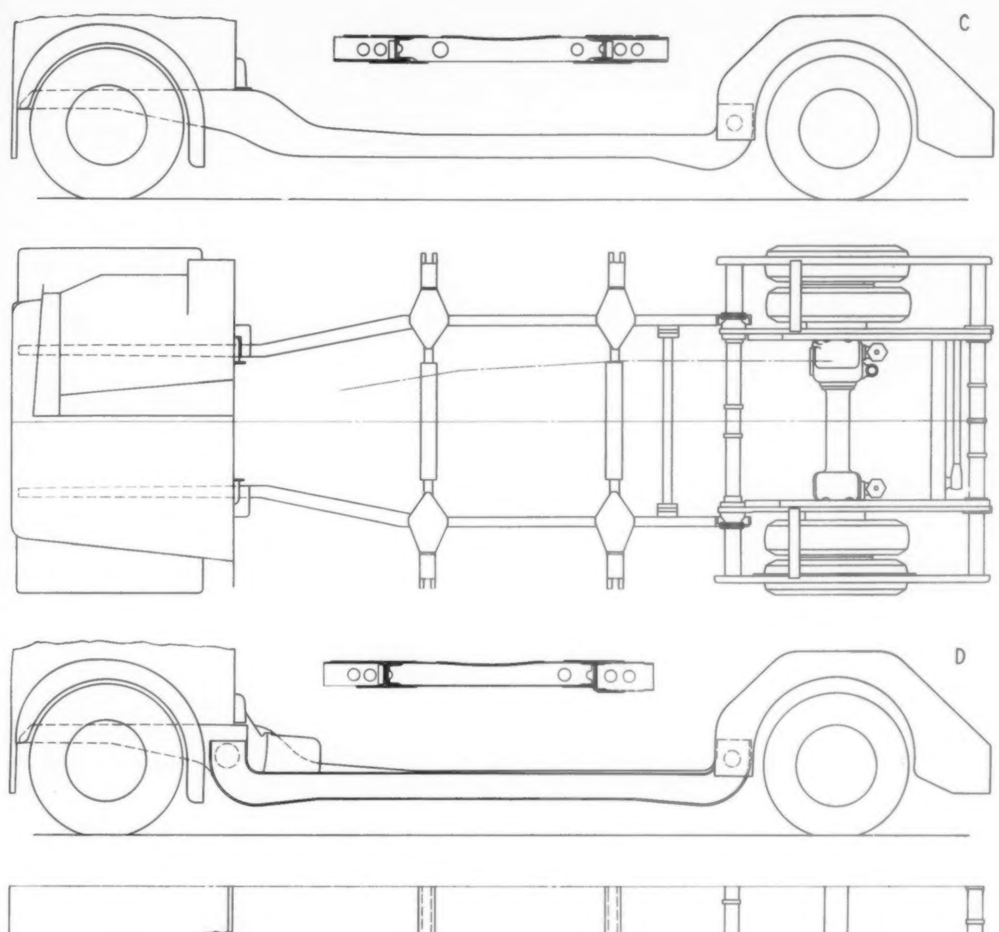


production of orthodox high-bridge vehicles ceased soon after. To date, about 2,000 have been built to the old 27×8 ft dimensions, mostly of the 60-seat type, for the two groups mentioned earlier. Additionally, a relatively small number of 70-seat vehicles has been built to the later 30×8 ft dimensional specification.

The Flat Floor design

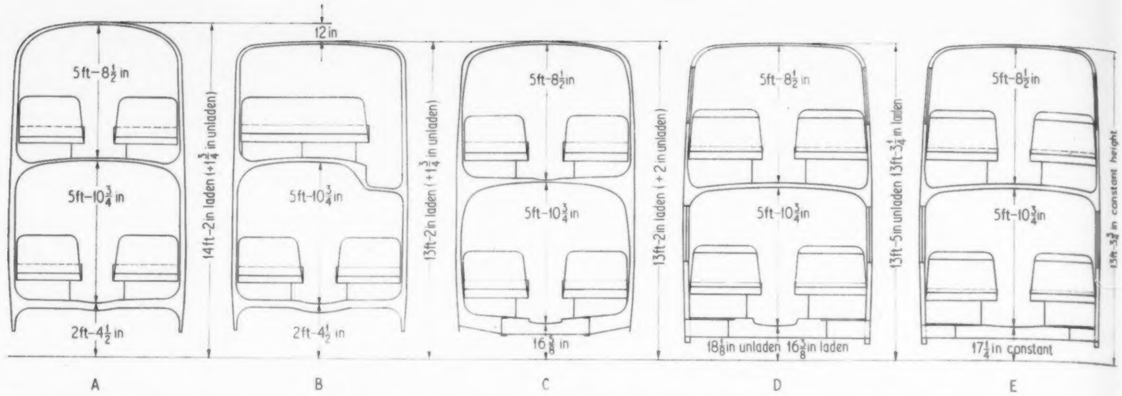
The standard Lodekka bus described has a rear entrance, with a single step from the road to the platform, which is slightly ramped to the height of the gangway of the lower saloon. As has already been stated, however, the general floor level below the seats is several inches higher than the gangway. A second development programme was therefore undertaken some time ago with the object of eliminating this difference in floor height. The result of that programme is the Flat Floor Lodekka, again a joint Bristol and E.C.W. construction. Two prototypes, one 27 ft and the other 30 ft long, have been built and are in service with the Tilling group.

On this design, a substantially flat floor has been obtained in the lower saloon by major modifications to the chassis frame, involving an unusual rear wheel arch that is integrated with the side structure of the body at the time when this is fitted. The frame side members of the standard Lodekka, though carried nearer the ground than normal, are of orthodox type with an up-sweep over the rear axle; at the back there is a horizontal portion supporting the platform. In contrast, the side members of the frame of the Flat Floor



A *prototype Lodekka chassis, with divided transmission;* **B** *standard Lodekka, with modified transmission;* **C** *rear entrance Flat Floor Lodekka;* **D** *Flat Floor Lodekka with side member modified for two-step forward entrance;* **E** *further modification to Flat Floor model for single-step forward entrance*

The development stages of the Lodekka chassis are indicated by the drawings reproduced on this and the preceding page



__A__ standard high-bridge bus; __B__ standard low-bridge bus with dropped gangway for upper saloon; __C__ prototype Lodekka design, with normal seating; __D__ standard production Lodekka; __E__ Flat Floor Lodekka, with air suspension

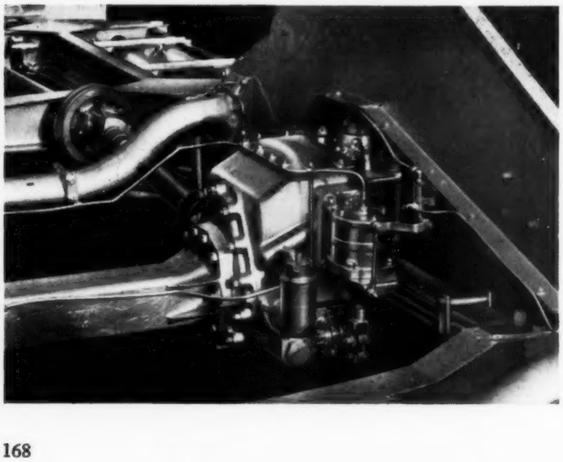
Overall, saloon and lower gangway heights of the standard high-bridge and low-bridge buses, and of the three Bristol-E.C.W. Lodekka types

vehicle are of shallower section, with a lower top flange, and terminate in a short upturned portion ahead of the rear axle and just inboard of the wheels.

The two fabricated cross members bridging the horizontal run of the side members have only a very small concavity in their upper faces, to obtain the necessary floor to ceiling height of 5 ft 10$\frac{3}{4}$ in. As on the standard Lodekka, the bolted-on body support brackets form extensions of the cross members. They are of double-channel construction and are braced to the side and cross members by riveted-on diamond-shape tension plates above and below.

Between the upswept rear ends of the side members is a bolted-on tubular cross member, downswept in the middle to the floor level. It is extended outboard of the frame by short tubular members attached by the same bolts. The inner, heel-board portions of the wheel arch structure are bolted to flanges on the cross member; they are made from 12 S.W.G. steel sheet and are of deep Z section, with the upper flanges turned outwards. Of $\frac{3}{16}$ in sheet, the channel-section outer portions of the structure are bolted at their forward ends to the cross member extensions. The two portions of each wheel arch assembly are connected by two intermediate cross members and by a full-width, tubular cross member at the rear, also downswept in the middle. Reference was made earlier to the integration of the outer portions of the wheel arch structure to the body, which thereby reinforces the rear end of the frame. Because of the unorthodox nature of the structure, the rear entrance platform is no longer supported on the frame, as on the standard Lodekka, but forms part of the body.

A torsional vibration damper is fitted between the two stages of the propeller shaft. The right-hand gear case of the axle is very compact



Air suspension

The weight variation between the light and the fully laden conditions is, of course, considerable with a public service vehicle. It follows that, with orthodox leaf spring rear suspension, a spring rate high enough to avoid excessive axle movement with a full passenger load results in a harsh action in the lightly laden state. For this reason, the two prototype Flat Floor Lodekka buses have been fitted experimentally with air suspension on the rear axle, and levelling valves are incorporated.

Apart from catering for variations in load, the air suspension provides a secondary benefit: the automatic levelling compensates for differences in the loading on the two pairs of rear wheels, owing to the passengers favouring, for any reason, one side of the vehicle. Since normal suspension might be preferred in certain circumstances, however, the manufacturers of the vehicle have decided to make either it or the air springing optional on the production Flat Floor models. In consequence, the design has been worked out with easy interchangeability of the two systems in view. The only major difference to the chassis frame is in respect of the tubular rear cross member: in the case of the leaf spring specification, it is mounted a little further forward on the wheel arch structure and embodies the anchorage for the spring shackles.

An unusual feature of the air suspension layout is that the axle is carried on what amounts to a torsionally flexible, pivoted sub-frame. This sub-frame comprises two longitudinal arms, in the form of very stiff semi-elliptic leaf springs, having four leaves, and a transverse beam of I section. The springs have normal eyes at the front, pivoting on pins carried in brackets on the tubular cross member ahead of the rear wheels. U-bolts attach the springs to the underside of the axle, outboard of the gear cases, and at the rear the springs are clamped to the transverse beam on which the air springs seat; they actually pass through slots in its web and are bolted to the flanges, which are locally reinforced. The springs locate the axle longitudinally, and absorb driving and braking torque reactions, while lateral location is effected by a Panhard rod. This is connected between the left-hand side of the I beam and the right-hand side of the rear cross member of the frame.

In comparison with the leaf springing, the air suspension

affords increased roll resistance by virtue of the wide spacing of the spring units. Whereas the orthodox leaf springs have the same transverse spacing as have the resilient trailing arms of the air springing, the air elements are sited directly behind the wheels, between the two side members of the wheel arch structure. Their lower ends are attached to the transverse beam and their upper ends to bridge members, of inverted top-hat section. The web of each bridge member is pierced outboard of the air spring to provide clearance for a hydraulic damper connected to the beam and the outer wheel arch member. Between the axle and the inner wheel arch members are mounted the two levelling valves.

The air springs are of the rolling seal type and are manufactured by the Andre Rubber Co. To give a constant periodicity of about 90 cycles/min, each spring is connected to a surge tank mounted immediately above it. The air supply source for the springs is a reservoir mounted in parallel with the brake system reservoirs and maintained at 80 to 85 lb/in². An air filter is fitted in the pipeline between the reservoir and the levelling valves. The use of small bore piping in the system avoids excessive air consumption and over-sensitivity to transient axle movements.

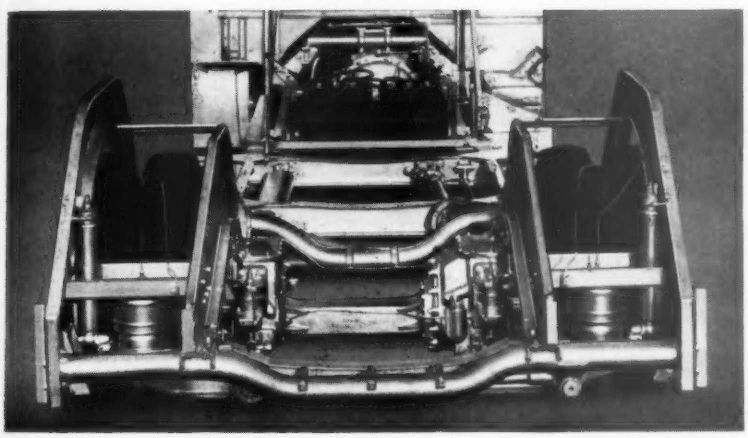
The braking system

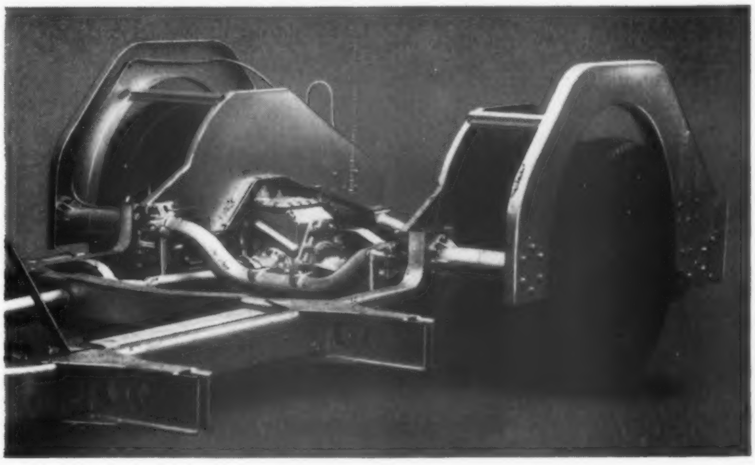
Another major difference between the standard and the Flat Floor Lodekka buses is in their braking systems. The earlier version is fitted with a triple vacuum servo layout, whereas on the Flat Floor model a combined air and hydraulic system is used. It is pointed out by Bristol that the triple servo system was designed for 26 ft × 7 ft 6 in vehicles, on which it gave a stopping efficiency of about 55 per cent—equivalent to 55 ft from 30 m.p.h. The percentage retardation quoted is the overall figure, not that recorded by Tapley meter; this was appreciably higher because of the time lag in evacuating the servos. Moreover, in obtaining maximum braking on the standard Lodekka buses, a pedal load approaching 200 lb was necessary.

With the introduction of the larger vehicles, capable of higher road speeds, an endeavour was made to equal this braking performance by fitting larger servos and reservoir, in spite of the difficulty of installing them. Higher readings were obtained with the Tapley meter, but the stopping distances showed no improvement. This was attributable to the still longer time lag owing to the greater servo volume.

A fundamentally better system was therefore sought when the Flat Floor vehicle was still in the design stage. Since good results had been attained with a dual air braking layout tried on some of the 30×8 ft vehicles, and because compressed air would be needed for the envisaged air suspension, it was logical to use this medium for the brake actuation. A combined air and hydraulic system was chosen rather than full air operation because of its shorter inherent lag, greater ease of accommodation, lower pedal pressure and, by no means unimportant, lower cost. In comparison with the vacuum servo scheme, the combined system has a better reserve in the unlikely event of failure of the power supply.

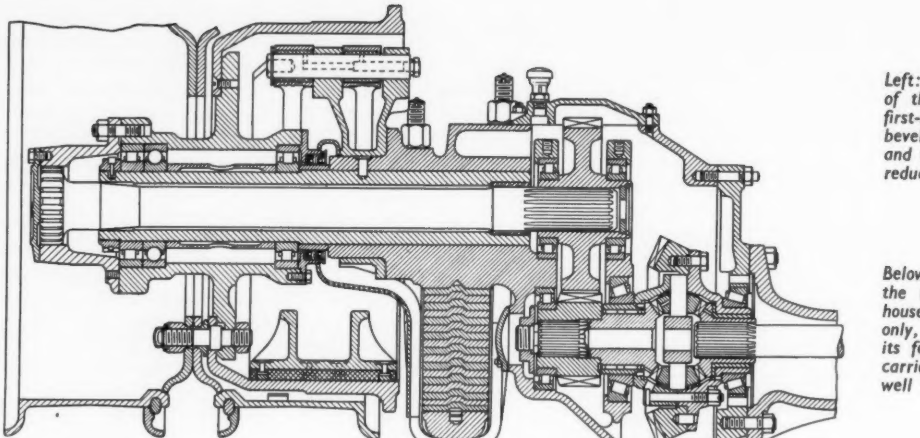
The layout embodies independent circuits, including separate air reservoirs, for the front and rear brakes. Movement of the brake pedal actuates a dual valve connected to these reservoirs, and allows air to pass to the two diaphragms controlling the hydraulic master cylinders. One of these master cylinders operates the front brake slave cylinders, mounted on the stub axles, while the other operates the frame-mounted slave cylinders for the rear brakes. A mechanical connection is employed between the slave cylinders and the brake units. By locating the master cylinders remote from the brakes, boiling of the fluid in arduous conditions is obviated. The nominal air pressure in the





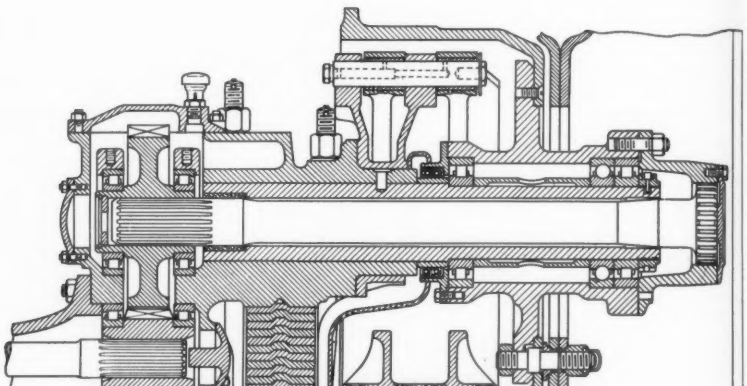
Above: The air suspension units and the telescopic dampers are situated behind the rear wheels and between the two members of the wheel arch structure. In the final version, surge tanks will be installed immediately above the two air springs

Right: This illustration shows the frame cross members, the body support brackets and the duplex wheel arch construction, with its anchorage to the tubular cross member ahead of the rear axle assembly



Left: The right-hand gear case of the rear axle contains the first-stage reduction, by spiral bevels, also the differential and the spur gear second-stage reduction to the output shaft

Below: At the left-hand end of the rear axle, the gear case houses a second-stage reduction only, identical in design with its fellow. Each wheel hub is carried on one ball bearing as well as on two roller bearings



reservoirs is 110 lb/in², and the maximum hydraulic pressure used is in the region of 960 lb/in².

A reduction in brake drum diameter, from the 17¼ in of the standard Lodekka to 16½ in, has resulted in more rigid drums and better cooling because of the improved air circulation. The new system has proved very satisfactory, with adequate but not excessive power. Stopping efficiencies of up to 55 per cent are obtainable without resulting in Tapley readings of over 60 per cent. Also, full braking does not require appreciably more than 100 lb pedal effort, a valuable point in reducing driver fatigue, while the pedal travel is sufficiently long for sensitivity of control.

Forward entrance designs

The third phase in the development of the Lodekka began about eighteen months ago, when attention was turned from the rear entrance layout to the forward entrance then being favoured by certain operators. In co-operation with Eastern Coach Works, a forward entrance bus was designed and, as a first stage, the frame of a Flat Floor Lodekka was modified to accommodate a body of this kind, with a two-step entrance. The method of modifying the frame is of considerable interest. A forward entrance could not be incorporated on the normal Flat Floor chassis because of the upsweep of the left-hand side member of the frame alongside the gearbox. To overcome this difficulty, a new side member was produced, having out-turned flanges. This new side member is straight in plan view and it continues substantially horizontal to a point beside the clutch housing; at this point it turns upward in a similar manner to the rear end. The changed design was necessary to bring the side member outside the 10 in ground clearance area required by the Construction and Use regulations. It could then be of the deeper section required to compensate for the interrupted waist rail, unavoidable with the forward entrance.

A short, tubular connecting member unites the upswept end of the side member to the engine-bearer portion of the frame. This portion has been modified by extending it rearward to the first cross member, to which it is attached; it dips sharply behind the cross tube, to bring its upper face to floor level. The extension of the engine bearer is necessary not only to provide an adequate strength of joint between it and the side member, but also to furnish additional support of the loading platform.

At this time, the Tilling group had not definitely decided to adopt the forward entrance Lodekka. However, as Dennis Brothers had received a request from an operator for such a vehicle, the Bristol design was passed over to them. A vehicle was duly produced to that specification and, as already stated, was exhibited at the 1958 Commercial Vehicle Show.

It was realized by both the chassis and the body manufacturers that this design threw away an important advantage of the standard Lodekka, namely, the single-step entrance. The final development stage has therefore been the evolution of a chassis frame that will accept a single-step, forward entry body. This has been achieved with a large measure of interchangeability with the rear entrance Flat Floor design, the major differences being in the construction of the left-hand side member and the first cross member.

In its general construction, the single-step frame resembles the two-step assembly. However, the forward portion of the left-hand main side member is downswept by 3¼ in, to give

a convenient step height, and is converted to I section by a secondary, back-to-back channel member. The downsweep and reinforcement extend from the turned-up forward end to the first cross member. A slightly greater drop than before is given to the rearward extension of the engine-bearer member so that its upper face is a little higher than that of the main side member. Thus, the platform is given a gentle upward slope from the step to the gangway. The first cross member had to be carefully redesigned to avoid any obstruction of access to the stairs or the lower saloon. This latest design will go into production alongside the rear entrance Flat Floor model, and it is expected that the first batch of twenty should go into service this year.

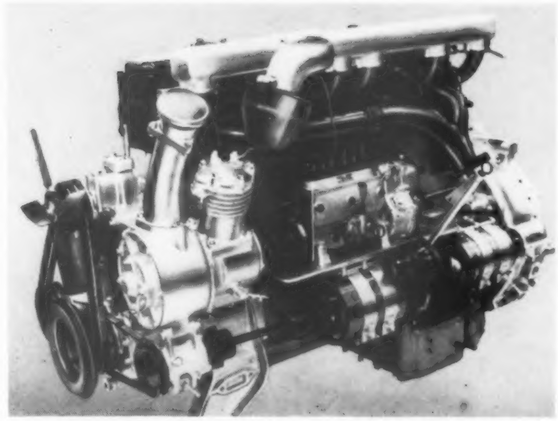
Power unit, clutch and gearbox

So far, no mention has been made of the front suspension, steering and other chassis features of the Lodekka, since these follow normal practice. However, it should be recorded that, following the usual Bristol plan, a choice is offered of the 8·4-litre Gardner 6LW engine or the Bristol 8·9-litre BVW six-cylinder unit. This latter has been developed from the long-established 8·14-litre AVW engine, but differs from it in several important respects. The increased swept volume has been obtained by enlarging the bore from 110 mm to 115 mm; the stroke remains at 143 mm, but the intermediate bearings of the seven-bearing counterbalanced crankshaft have been lengthened to deal with the increase of output from 97 to 115 b.h.p. at 1,700 r.p.m. Whereas the earlier engine featured a separate cylinder block and crankcase, the BVW has a one-piece block and crankcase casting. Also, wet cylinder liners replace the pressed-in dry liners of the AVW. As before, each group of three cylinders has its own head.

Another major change concerns the drive to the camshaft and auxiliaries. This is now entirely by helical gears, whereas formerly a chain drive arrangement was employed, but with a gear drive to the oil pump. Filtration of the lubricant is effected by means of the highly efficient Glacier Metal centrifugal filter. An unusual feature of the engine is that no water passes through the cylinder head gasket, from the block to the head; instead, the coolant flows through external ducts from one water jacket to the other. This obviates the possibility of internal leakage.

The $16\frac{1}{2}$ in diameter clutch is of Bristol design. Its friction plate is attached to a splined hub carried on the extended input shaft of the gearbox. A renewable wearing plate of Chromidium cast iron is bolted to the flywheel, in the centre of which is a ball bearing to support the end of the input shaft. Running directly on the shaft is the sleeve of the ball thrust bearing for clutch withdrawal; the sleeve is fitted with an Oilite bush and actuates three toggle levers. These levers bear on replaceable pads on the pressure plate, which also is a Chromidium casting; the pads have a four-position mounting to permit adjustment for wear. A clutch brake is embodied in the design.

A four-speed or five-speed gearbox, each having a common casing, can be fitted, according to the operational requirements. The gears of all the forward ratios are of the constant-



The Bristol BVW six-cylinder engine has a swept volume of 8·9 litres

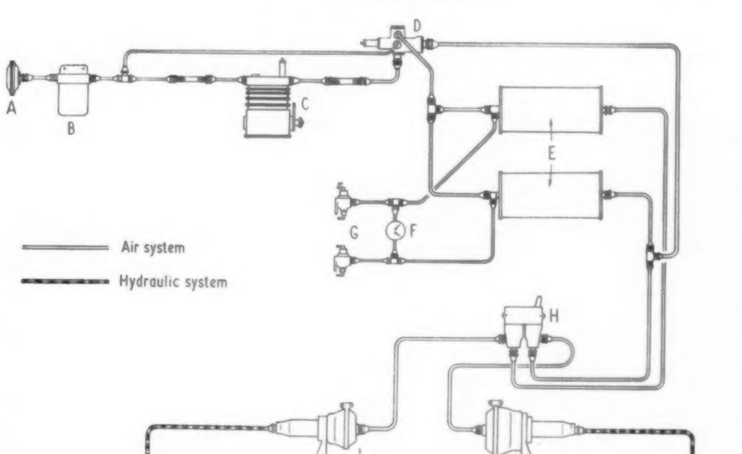
mesh type; a diametral pitch of 5 is employed throughout, and on the upper two or three ratios the tooth form has a long addendum. Where a fifth ratio is employed, it provides a step-up of 0·97 : 1. The other ratios are common to both types of gearbox and are as follows: fourth, 1·26 : 1; third, 2·05 : 1; second, 3·44 : 1; first, 5·97 : 1; reverse 5·59 : 1.

Heating

Where the standard heating equipment is specified, a Clayton Dewandre unit of normal design is fitted in each

Diagrammatic layout of the combined air and hydraulic braking system of the Flat Floor Lodekka

A air filters; B air anti-freeze device; C compressor; D unloader valve; E air reservoirs; F dual pressure gauge; G low-pressure indicators, connected to buzzer and warning lights; H dual brake valve; J brake chamber and hydraulic master cylinder, front brakes; K brake chamber and hydraulic master cylinder, rear brakes; L front brake slave cylinders; M rear brake slave cylinders



saloon. As an alternative, the efficient Cave-Brown-Cave type of installation can be incorporated. It comprises two radiators, one on each side of the destination indicator box, level with the floor of the upper saloon; the regulation of the heat supply from these radiators to the saloons is effected by means of flaps and louvres, under the driver's control.

Induction Heating in Component Manufacture

Standard and Special Wild-Barfield Equipment, Including Examples of Integration with Machine Tools and Assembly Lines

COMPARED with other forms of industrial heating, induction heating enjoys a two-fold advantage. It is inherently clean and there is an absence of extraneous heat, since heat is generated only in the component undergoing treatment. The process may be used, therefore, in the workshop in the actual production or assembly line, and transport to and from a segregated heat-treatment shop can be eliminated. In the majority of installations, jigging fixtures locate the work, and current and timing are automatically controlled, thereby calling only for unskilled labour. The cleanliness and the absence of heat and fumes render it entirely practical for female labour. In suitable instances, equipment can be provided for the automatic feeding, loading, quenching and unloading of the work-pieces, and a single operator can tend several treatment machines.

The process is extensively used in the automobile manufacturing and supply industries, where it is employed on repetition hardening, local softening, silver soldering and soft soldering. It also finds application for preheating for forging, upsetting, and shrinking operations. Equipment involved usually comprises an induction heating generator, an inductor coil and a work fixture. The many different types of fixtures may be conveniently divided into six broad classes:

1. Hand loading and unloading.
2. Hand loading with automatic ejection.
3. Magazine feed with automatic ejection.
4. Hopper feed with automatic ejection.
5. Incorporation of induction heating process on one or more stations of an automatic transfer machine.
6. Incorporation of induction heating process into a standard machine tool, such as a multi-spindle automatic lathe.

Hardening

Undoubtedly, the most important application of the induction heating process in the automobile industry is that of hardening. The characteristics of the process can be exploited to the full, so that local hardening and surface hardening may be undertaken; the former by reason of rapid heat generation, and the latter because heat is generated only in the outer surface. Where possible self-hardening, plain carbon steels are used, the most popular in Great Britain being En 8d (0·4-0·45 per cent C, 0·7-0·9 per cent Mn). It is suitable for water quenching, and a surface hardness of 59 Rockwell C can readily be obtained on this type of steel without danger of cracking.

In some cases components are carburized and locally hardened by induction heating. By this means it is possible to reduce costs by carburizing the component without plating or other methods of stopping off. At the same time, since frequently only a small portion of the component requires final hardening, a considerable reduction of the

Fig. 1. Two-station manual loading and unloading fixture for hardening push-rod cup and ball ends

Fig. 2. Semi-automatic fixture for the hardening of pads on overhead valve rocker levers

distortion that would normally occur during final heating and quenching is effected. An alternative production method with carburized components is to harden all over by conventional furnace methods and use induction heating for subsequent local softening where necessary, for instance, on screw threads.

With self-hardening steels it has been found satisfactory, in most cases, to employ hardened case depths of the order of 0·75 to 1 mm. This provides an adequate allowance for final grinding and, generally, leaves a large core of steel unaffected by the hardening process.

A point to be borne in mind when considering induction heating and the capital cost involved, is that savings accrue not only in the actual process, but also in subsequent operations. In many cases distortion is considerably reduced: thus grinding allowances can be less, with the result that grinding times are shorter and wheel life longer. Moreover, scaling is usually completely eliminated, there being only a very thin oxide film adhering to the component after treatment.

In Fig. 1 is illustrated a two-station, hand loading and unloading fixture for the hardening of cup and ball ends of push rods. It is equipped with a heat timer, quench timer, and power control on each station so that stations may be individually set up for the operations. In the case shown, the left-hand station is set up for the hardening of ball ends—three components simultaneously—with a heating time of 3 seconds, and the right for hardening cup ends, again three components simultaneously, but with a heating time of 7 seconds. Power is supplied by a $7\frac{1}{2}$ kW generator, and a production rate of 540 completely hardened components per hour is attained.

As may be seen, the fixture is a very simple one, yet it enables unskilled labour to produce components hardened under completely controlled conditions. Two foot switches are provided, one for each station, so that the operator can unload and load one whilst the heat-treatment cycle is taking place on the other. The system is arranged so that as soon as loading is completed, the appropriate foot switch

Fig. 4. Machine for hardening brake-adjusting conical pins

is operated, enabling the machine to perform the heating cycle automatically as soon as the heating cycle at the other station has been completed.

Fig. 2 illustrates a $7\frac{1}{2}$ kW induction-heating generator to which is mounted a semi-automatic fixture for hardening the pads on valve rocker arms. The unit consists of a continuously rotating turntable upon which are mounted 20 location jigs. These jigs are loaded individually by the operator and automatically clamp the components in the bore of the centre hole. Whilst so clamped they are automatically aligned for height in relation to the inductor or work coil. After alignment, the parts pass under a single-turn, slip-type inductor which heats the pads to the

Fig. 3. Progressive hardening unit for treating pre-selected bands on valve-rocker shafts

Fig. 5. 15 kW generator set up with two semi-automatic fixtures

Fig. 6. Equipment for handling striking levers

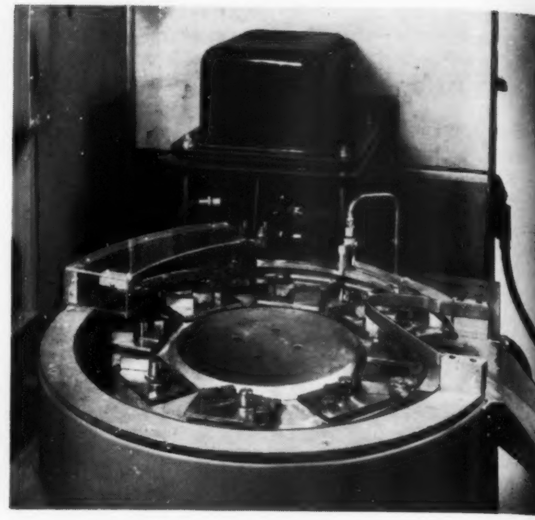


Fig. 7. Set-up for treating selector forks

required temperature. Upon leaving the inductor they are immediately spray-quenched and then automatically ejected from the machine. The production rate is approximately 20 components per minute, and the function of the operator in this case is merely to load the components.

Progressive hardening of rocker shafts is carried out in the machine shown in Fig. 3. The hardened bands may be discerned on the component being unloaded by the operator. This serves as an example of the induction heating process being used in the production flow line. The components are delivered to the hardening units on a roller conveyor direct from the initial machining operations, and after hardening they are transferred direct to straightening and grinding stages.

In this case, the duty of the operator is to place the rocker shafts between centres and press an initiation button. Thereafter the cycle is completely automatic. The component is carried at high speed up through the inductor, and at the top of the stroke it starts to rotate and quenching water is switched on. It is then fed downwards through the inductor at a pre-set hardening speed. The high frequency power is switched on and off automatically, by means of a switch mounted on the fixture, and a plate cam to give the desired hardness pattern.

The indexing turntable type of equipment shown in Fig. 4 is employed for hardening brake-adjusting conical pins, which are loaded by hand. Operation is automatic, pairs of components are indexed under the twin inductor

Fig. 8. Magazine type of equipment for handling shafts. Covers removed to show operating cams

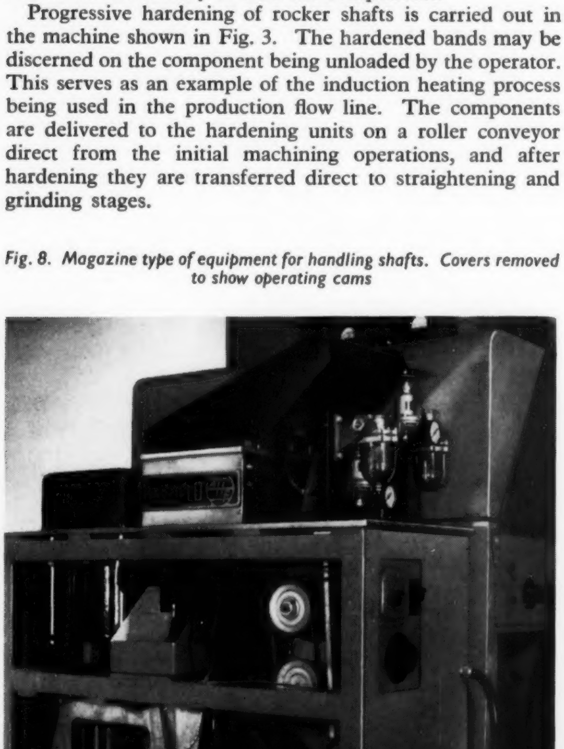
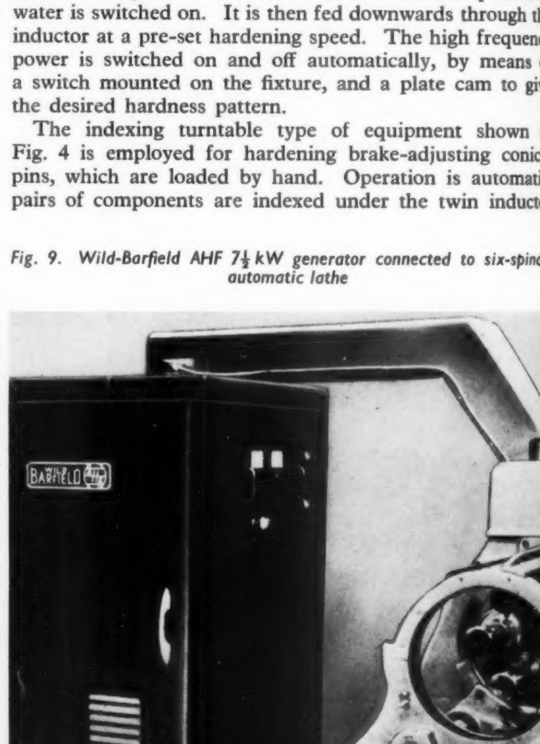


Fig. 9. Wild-Barfield AHF $7\frac{1}{2}$ kW generator connected to six-spindle automatic lathe



and the table rises to lift the parts into position. Heating and quenching cycles are then performed under the control of timers, after which the table falls and indexes to the next position. Hardened components are ejected automatically. The unit is capable of an output of approximately 1,000 hardened brake-adjusting pins per hour.

A 15 kW induction heating generator in Fig. 5 is equipped with two semi-automatic fixtures. These are permanently set up for specific operations and either may be used at will by pressing an associated start button. Interlocking allows only one fixture to be used at a time. When a particular start button is pressed, the associated fixture is automatically connected to the generator and the appropriate power control is selected. In the case of the left-hand fixture, the timers mounted on the generator are also brought into operation, no timers being necessary for that on the right. This equipment is used for hardening gearbox components; the left-hand fixture for striking levers and the right-hand one for selector forks.

The striking lever fixture, Fig. 6, is of the indexing type, components being hand loaded. The table indexes automatically at pre-set intervals, the inductor moves forward into position at the end of each indexing operation, and the timers control automatically the heat and quench cycle. The right-hand fixture for the hardening of selector forks is of the continuously rotating table type. Components are loaded by hand and pass through a slip-type inductor, and then through a continuous spray quench, see Fig. 7. Automatic ejection of hardened parts is common to both these fixtures.

An example of a magazine-loading type of equipment is shown in Fig. 8. It was designed for the fully automatic induction hardening of shafts, and can be set up to handle two different types of shaft. In operation, the components are automatically fed from the magazine into a guide chute, and thence into guides where they pass through the inductor and quench. The rate of travel through the inductor is controlled by cams. Automatic ejection at the bottom of the stroke is effected by the cam riser, which pushes the components out through spring-loaded guides. By this means continuous hardening of components is achieved, the high frequency power being switched on and off by means of micro switches operated by subsidiary cams on the main camshaft.

An interesting application is shown in Fig. 9, which illustrates a $7\frac{1}{2}$ kW generator connected to a six-spindle automatic lathe for the production of valve rocker adjustment screws at a rate of 514 components per hour. The unit completely machines, burnishes, thread rolls, induction hardens, and saw-slots the parts; the arrangement eliminating the need for a separate hardening operation.

Soft soldering and hard soldering

Although numerous applications for soft soldering and silver soldering occur in the motor industry, in most cases these are not suitable for mechanization, and essentially simple fixtures with hand loading and unloading are provided. An installation of three induction heaters employed on the soft soldering of brake tank assemblies is shown in Fig. 10. These equipments solder main cylinders into fluid tanks. To ensure that the tank is fluid tight, two soldered joints have to be made, and as the joints are on opposite sides of the tank, it is necessary for the soldering to be carried out in two operations.

The fixture consists of an insulated top plate, beneath which is mounted a high frequency transformer connected to two inductors which project through the top plate. They are fully insulated to form spigots upon which the components are placed so that the inductor enters the cylinder and heats it internally. To ensure that the tank is positioned correctly relative to the cylinder units being soldered, small location jigs are used. These two inductors on each machine are adapted for the two operations required, and operations are carried out simultaneously on two separate assemblies, so that the completely soldered unit is produced by each equipment on each cycle.

Upon occasion, units are required to carry out both soft soldering and silver soldering. Such an equipment is shown in Fig. 11. It comprises a 3 kW generator with the right-hand station arranged for silver soldering and the left-hand station for soft soldering. The right-hand station joins nipples to copper pipe and produces the components three at a time. In the illustrations the equipment is in the loading position, with the location spigot raised through the inductor. The three assemblies are each placed in position with a nipple located on the spigot and the top of the copper pipe held by means of a spring clip. The loaded carrier is then lowered, carrying the three components into

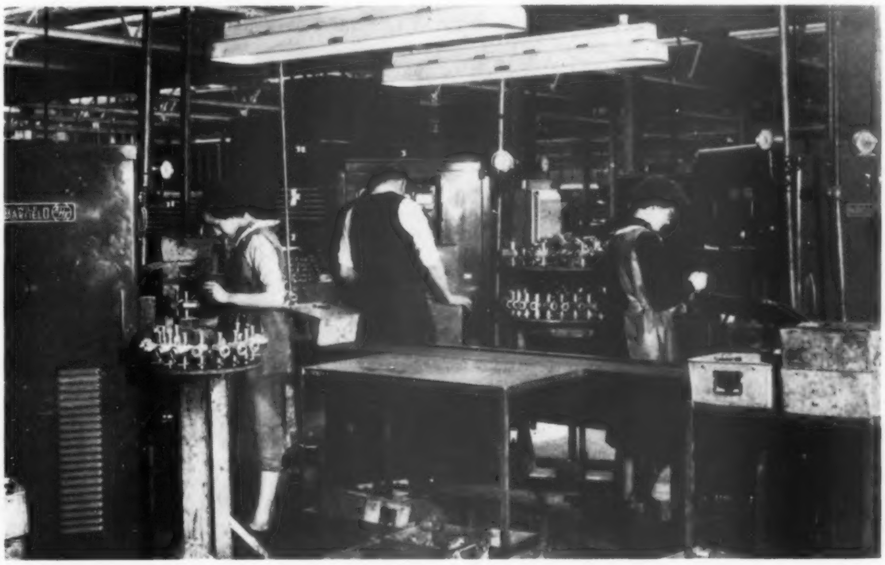


Fig. 10. Installation for soldering brake tank assemblies

Fig. 11. 3 kW generator and fixtures for hard- and soft-soldering nipples to tubes

the inductor, where the soldering is controlled by means of a timer mounted in the fixture. Upon completion of the heating operation, the carrier is raised to remove the components from the inductor so that they may be taken from the fixture, which can then be reloaded with fresh parts.

The left-hand station is used for soft soldering nipples on to copper pipes, the nipple being slid over the pipe and located approximately midway along its length. Five such assemblies are loaded in a troughed fixture and are soldered in one operation. This installation affords another example of two-station operation, which enables loading and unloading to take place on one station whilst the heating cycle is taking place on the other. Apart from its merits in relation to production, it ensures better utilization of the induction heating generator.

While the foregoing examples are typical of soldering applications carried out by induction heating, in some instances partial mechanization can be achieved by utilizing equipment such as conveyor belts or indexing tables. A certain amount of manual work must, however, be involved due to the necessity of fluxing and the placing of solder rings or pellets. Thus, when a handling fixture is designed, it should be borne in mind that it is nearly always necessary to employ an operator for these operations. In many instances, this operator has sufficient time available to load and unload the machine, so that it is then not necessary to have any complicated handling mechanism to add to capital costs without increasing the rate of production.

As previously mentioned, the use of induction heating is not confined solely to hardening and soldering. Many other applications are being found in the automobile industry. Experience has shown that modern induction heaters are thoroughly reliable tools, which can readily be adapted to numerous operations and processes where heat is required. Moreover, such operations may be carried out repetitively without attention once equipments are set up. Consequently, unskilled labour may well be used, not only to increase the rate of production, but also to lower costs.

Duraband R.B.1. Tyre

UNTIL recently, the Duraband R.B.1 tyre, manufactured by the Dunlop Rubber Co. Ltd., of Erdington, Birmingham, 24, has been available only to rally drivers. However, it has now been released for general sale. This tyre has a braced tread and a very flexible casing. These features combined give good resistance to distortion, particularly during fast cornering. Under these conditions the tyre drifts less and wears more slowly than conventional ones.

The Duraband tyre is designed primarily for sports cars, but will also appeal to some owners of saloon cars who experience motoring conditions likely to cause rapid tyre wear. It is pointed out, however, that braced tread tyres have certain limitations. They tend to make steering at low speeds heavy and, below 40 m.p.h., the ride is noticeably harder than with more conventional tyres. Also, at high cornering speeds when the limit of adhesion is reached, there is the possibility of abrupt break away.

British Standard

A NEW publication has been prepared to facilitate the production and interchange of main friction clutches, main power-take-off assemblies and associated attachments for internal combustion engines, other than aircraft engines. It is B.S.3092:1959, Dimensions of Main Friction Clutches, Main Power-Take-Off Assemblies and Associated Attachments. The need for interchangeability has necessitated the consideration of current American practice and in certain instances American standard dimensions have been adopted.

In the Standard are specified envelope, attachment and certain other dimensions of fly-wheel-mounted main drive components for internal combustion engines. This 46-page illustrated publication refers to several types of main clutches and power-take-off assemblies, fly-wheel spigoted couplings, and engine fly-wheel and clutch housings. It also refers to splines for clutch hubs, and to spigot bearings, dowels and tolerances; in addition, it includes an identification code recommended for use in documentation. Copies can be obtained from the British Standards Institution, Sales Branch, 2, Park Street, London, W.1. Price 12s 6d. Postage will be charged extra to non-subscribers.

Mobil Oil Company Films

TWO NEW FILMS, entitled *Lubricants With Care* and *Compressor Lubrication* are now available from the Industrial Division of the Mobil Oil Co. Ltd., Caxton House, Westminster, London, S.W.1. These films are the sixth and seventh in a series of industrial films being made by the various European companies of the Mobil group. Both were made abroad and have won awards in their respective countries: *Lubricants With Care* was made by Mobil Oil Francaise and the other by Mobil Oil Italiana. The English versions have, of course, been prepared in this country.

In *Lubricants With Care*, the manufacture, transportation, storage, application and reclamation of high-grade lubricants are dealt with. *Compressor Lubrication* covers the operating principles and the lubrication of all types of compressors, including both radial and axial types. Particular attention is paid to lubrication in relation to economic operation.

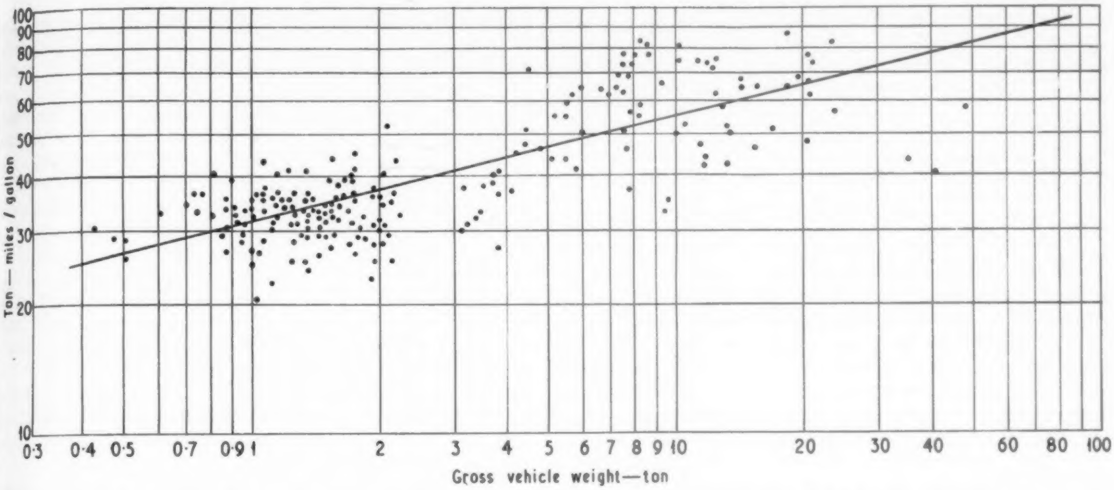


Fig. 1. Analysis of the average fuel consumption, over large mileages, of 245 different petrol-engined vehicles, from three-wheelers to heavy trucks

ROLLING RESISTANCE

An Analysis of the Principal Factors and the Existing Data

R. M. OGORKIEWICZ, M.Sc. (Eng.)

ONE of the essential preliminaries to car design is, of course, the prediction of performance and this, to a very large extent, hinges on an accurate assessment of rolling resistance. In spite of the important contribution made by aerodynamic drag to the forces resisting vehicle motion, particularly in the case of light cars, rolling resistance accounts for the major part of the total and this makes it of great importance in car design and automotive engineering in general.

Rolling resistance arises from the interaction between the running gear of the vehicle and the surface on which it operates. In the particular case of cars operating on hard surfaces, the interaction manifests itself primarily in the deformation of the tyres, and the rolling resistance arises mainly from this cause. As a vehicle moves and its wheels revolve, the deformation of every tyre changes continuously over its periphery and although the tyre deforms elastically, the forces involved in the loading and unloading of its elements are not completely reversible, so some energy is lost in each cycle of events. In other words, the work done in the repeated changes in the deformation of the tyre is not fully recovered, owing to elastic hysteresis losses, the energy lost being dissipated as heat.

The energy dissipated in a rolling tyre implies an absorption of work in moving a vehicle and the work done against the rolling losses is usually expressed in terms of a force opposing the motion of the vehicle. The resistance itself is commonly expressed per unit of load on the tyre, or as a specific rolling resistance, which greatly facilitates comparisons, but unfortunately there is a lack of uniformity in the units used. Thus, rolling resistance is quoted in technical literature as lb/ton, lb/1,000 lb, lb/lb, etc. The use of the same units for force and weight has much to recommend it, as it avoids possible confusion between long, short and metric tons and facilitates the use of results from different sources; it will therefore be used here.

Importance of weight

The common practice of expressing rolling resistance per unit of weight, or as a specific rolling resistance, not only facilitates comparisons but rests on the more fundamental reason that rolling resistance is a function of the load on a tyre, or vehicle weight. Thus, rolling resistance of a vehicle can be expressed in a manner analogous to the laws of sliding friction:

$$R = C_R W \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where R = rolling resistance of the vehicle, lb
W = weight of the vehicle, lb
C_R = a dimensionless coefficient, the coefficient of rolling resistance, or the specific rolling resistance, lb/lb

The coefficient of rolling resistance bears no relation, of course, to the coefficient of sliding friction and, as will be indicated, is a complicated function of the properties of the tyre and ground surface. Nevertheless, it is still common to regard it as a simple factor of proportionality and to assign to it a single numerical value of between 0·01 and 0·02; the mean value, 0·015 or 0·016, is commonly accepted for present-day cars operating on the normal hard road surfaces.

INDEX AND BINDING

The index to AUTOMOBILE ENGINEER *Volume XLVIII, January to December, 1958, is now available, price 6d, or by post 8d. Binding cases and index can be supplied separately, price 7s 6d, or by post 9s. Remittances should be sent to Dorset House, Stamford Street, London, S.E.1.*

We shall be pleased to undertake the binding, the cost being 25s per volume, including the binding case, index, and the return postage on the completed volume. The complete issues should be sent to Iliffe and Sons, Ltd., Binding Department, 4/4a Iliffe Yard, London, S.E.17, with a note of the sender's name and address enclosed. A separate note, confirming despatch, together with remittance, should be sent to the Publishing Department, Dorset House, Stamford Street, London, S.E.1.

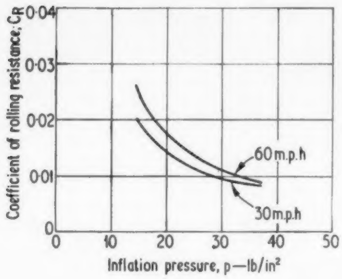


Fig. 2. These curves show that rolling resistance increases rapidly as the tyre pressure is decreased from 40 to 15 lb/in²

For some purposes such simple relationships are sufficiently accurate and weight alone can be used not only to obtain a measure of the rolling resistance but also a first approximation to the overall performance of a vehicle. For instance, analysis of the average fuel consumption over extended mileages of 245 different petrol-engined vehicles, ranging from light three-wheelers to heavy multi-wheel trucks, built during the past ten years, leads to a simple correlation with weight. The actual results are plotted in Fig. 1 in terms of ton-miles/gallon against gross vehicle weight in tons, both on a logarithmic scale, and the equation to the straight line, obtained by the method of least squares, is:

$$\text{Ton-miles/gallon} = 31{\cdot}5\ (\text{G.V.W.})^{0{\cdot}243} \quad \ldots\ldots\ldots\ldots(2)$$

where G.V.W. = gross vehicle weight.

In other words, given the laden weight of a vehicle, a measure of its average fuel consumption can be simply obtained from such a statistical analysis. The analysis also illustrates that it is not correct to regard the ton-miles/gallon as something independent of vehicle size, as is so often done in practice, and it indirectly shows the predominant influence of rolling resistance on vehicle performance.

Vehicle speed

Although simple relationships of the above type may be adequate for preliminary calculations, to obtain more accurate results and a better understanding of rolling resistance other factors must also be considered in addition to weight. The first additional factor that needs to be considered is the speed of the vehicle. It is well known that at high vehicle speeds rolling resistance is considerably higher than at low speeds, and for any given type of tyre, the relationship between rolling resistance and speed is usually approximated to by an expression of this form:

$$R = (a + bV^n)W \quad \ldots\ldots\ldots\ldots(3)$$

where a and b are constants for the tyre at a particular inflation pressure, and V is the vehicle speed. The index n is frequently given[1,2,3] as 1, but in a number of cases its value is quoted as 2, or even higher, as indicated below.

By comparison with equation (1) it can be seen that C_R, the coefficient of rolling resistance, varies with speed according to the terms in the bracket of equation (3) instead of having a constant value, that is:

$$C_{RV} = a + bV^n \quad \ldots\ldots\ldots\ldots(4)$$

In the cases where unity is quoted for n, a is given approximately the same numerical values as C_{RS}, the simple constant-value rolling resistance coefficient of equation (1), and b is of the order of 0·0001 when V is in m.p.h. For low vehicle speeds C_{RV} obviously tends to a constant value and approximates to C_{RS} whose quoted values in general apply only to low speeds.

Expressions of the type represented by equation (4) are probably sufficiently accurate, for most practical purposes, to represent the variation of the coefficient of rolling resistance with speed, but some experimental evidence suggests that rolling resistance remains in fact substantially constant up to a certain speed, and only then does it begin to increase with speed[4]. In other words, the implication is that, up to a certain rate of flexing, the energy dissipation per cycle is independent of the rate of strain and then it increases, owing to inertia losses.

An expression for rolling resistance, which would correspond to such a discontinuous law, has been quoted by Nagler and Razak[5], and in the terms used here gives:

$$C_R = 0{\cdot}0165 + 0{\cdot}000165\ (V - 30) \quad \ldots\ldots\ldots\ldots(5)$$

The second term of this equation is only considered when positive, but the speed of 30 m.p.h., at which transition occurs in this case, is well below the 50 m.p.h., or more, suggested by the results[4] of the experiments; this still holds good even when allowance is made for possible differences in inflation pressure, which governs the critical speed at which rolling resistance begins to increase significantly.

Inflation pressure

Examined in general as a function of inflation pressure, rolling resistance varies inversely with it, increasing rapidly as the inflation pressure is decreased, as indicated in Fig. 2. The increased resistance arises from the reduced stiffness of the tyre and the increased deformation for any given load, but it is worth noting that on soft ground, where rolling resistance is due to compression of the soil as well as flexing of the tyres, reductions in the inflation pressure have the opposite effect, that is, one of reducing the total rolling resistance.

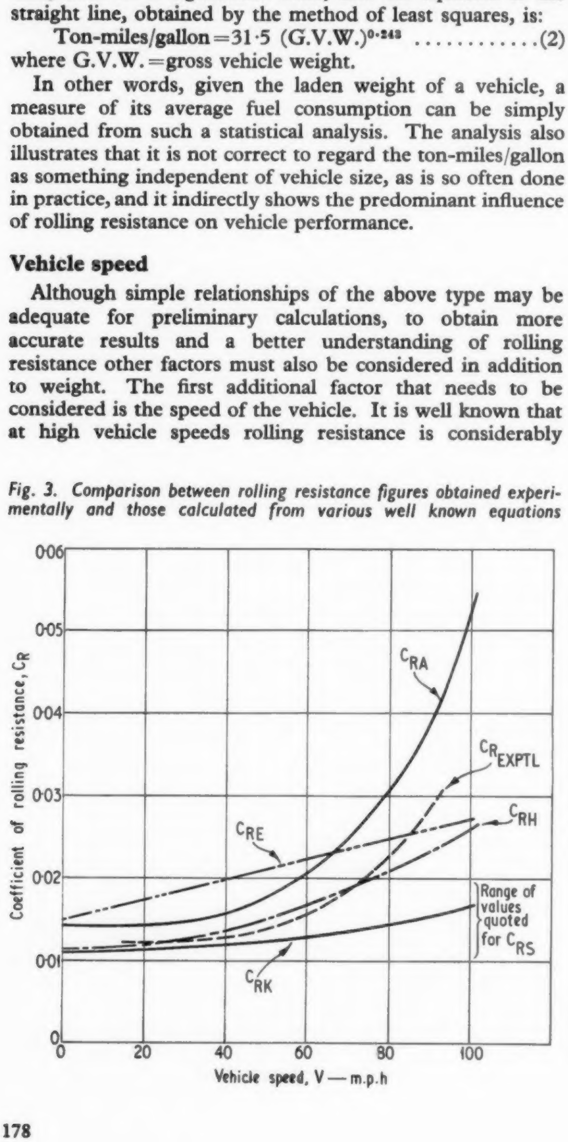
For car tyres running on hard surfaces, a comprehensive expression for rolling resistance, taking into account inflation pressure as well as speed, was evolved by Kamm[6]. It was derived from results obtained at the Stuttgart Research Institute more than twenty years ago and therefore the tyres used were considerably different from those in use at present, but it has been quoted in such recent works as those of Hadeke[7] and Bekker[8]. Converted into the units used here, it gives the rolling resistance coefficient as:

$$C_{RK} = 0{\cdot}0051 + \frac{0{\cdot}0809 + 0{\cdot}00012\ W_t}{p} + \frac{0{\cdot}105 + 0{\cdot}0000154\ W_t}{p}\left(\frac{V}{100}\right)^2 \quad \ldots(6)$$

where W_t is the load on the tyre in lb, and the subscript K is used to differentiate the coefficient given by this equation from others.

A similar but simpler expression, also based on German

Fig. 3. Comparison between rolling resistance figures obtained experimentally and those calculated from various well known equations



work done in the mid-thirties, has been given by Hoerner[9].

$$C_{RH}=0{\cdot}005+\frac{0{\cdot}15}{p}+\frac{0{\cdot}35}{p}\left(\frac{V}{100}\right)^{2} \quad \ldots\ldots\ldots\ldots(7)$$

Another expression, attributed to Andreau[10], which has been used fairly extensively in car design, is:

$$C_{RA}=\frac{0{\cdot}109}{p^{0{\cdot}64}}+\frac{0{\cdot}00565}{p^{2{\cdot}08}}\left(\frac{V}{10}\right)^{3{\cdot}7} \quad \ldots\ldots\ldots\ldots\ldots\ldots(8)$$

Although the general trend indicated by the three equations is similar, the results differ considerably, and it is of interest to compare them firstly with each other, secondly with an expression of the type referred to in connection with equation (4) and given below, and finally with a set of experimental results for the case of a typical tyre fitted to a car of 2,240 lb laden weight and 24 lb/in² inflation pressure.

$$C_{RE}=0{\cdot}015+0{\cdot}00012\ V \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(9)$$

The results are given in Fig. 3 and illustrate that for high speeds the values of the rolling resistance coefficient C_{RA}, obtained from the widely used Andreau equation, are too high. The graph also shows that equations in which the rolling resistance coefficient varies linearly with speed, as C_{RE} does here, do not represent the variation with speed correctly. In this case closest agreement with experimental results is obtained with Hoerner's equation for C_{RH}, whereas the constants of Kamm's equation for C_{RK} do not appear applicable to present-day car tyres.

Tyre diameter and ground surface

Another factor affecting rolling resistance is the diameter, or radius, of the tyre. The smaller the radius the greater is the number of flexing cycles per unit of time for any given vehicle speed, and if the energy dissipation per cycle were constant for a given range of tyre sizes then the rolling resistance would be inversely proportional to tyre radius. The energy dissipation is not in fact constant, but some work with tractor tyres on concrete, quoted by Barger and his co-authors[11], gives:

$$C_R=0{\cdot}96\ D^{-1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(10)$$

where D is the outside diameter of the tyre. In general, however, there is no agreement about the extent to which rolling resistance varies with speed, although it is agreed that it increases as the tyre radius decreases[12].

Moreover, tyre radius affects not only the rolling resistance of a free rolling tyre, that is, a tyre that does not transmit any torque, but also the losses that arise through slip between a torque-transmitting tyre and the ground surface. The amount of slip, and hence the losses, varies with the ratio of the tractive effort to load, and the shape of the contact area between the tyre and the ground surface. The importance of the tyre-ground contact area has been discussed at length by Bekker[8], but in general, the subject has still received little attention, and the relationship between it and tyre radius and traction efficiency has been almost ignored in motor vehicle design.

A further important factor affecting rolling resistance is the type and condition of the surface on which the tyre rolls. Although on hard surfaces, rolling resistance is caused chiefly by the energy dissipation in the tyre, the ground surface still has a considerable influence on it. For instance, values of C_{RS} given for new and worn road surfaces[13] are, in the case of asphalt, 0·010 and 0·020 respectively. Thus, the condition of the road surface can alter the value of the coefficient of rolling resistance by as much as 100 per cent.

The mechanism by which hard surfaces, to which attention is confined here, affect rolling resistance is not clear. In the case of the differences between wet and dry surfaces, the higher rolling resistance on wet surfaces is ascribed to the cooling effect of the surface water and the corresponding decrease in the flexibility of the tyre[12].

Tyre material and construction provide a further set of factors that affect rolling resistance. The amount of material that is deformed affects adversely rolling resistance and, in consequence, smooth worn tyres show lower values of C_R. The variables involved are too numerous, however, to be amenable to synthesis, and their examination must be confined to particular practical cases.

Although particular aspects of the problem could be elaborated further, enough has probably been said to indicate the main aspects of rolling resistance in relation to car design and to suggest where some further attention might be profitable. One particular problem in respect of which further attention seems desirable is that of tyre diameter. The latter has been reduced progressively over the years, chiefly in response to styling demands, and little consideration has been given to its influence on rolling resistance and traction; in general, rolling resistance merits much more attention than it has received hitherto.

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Rolling Element Bearings

TWO PUBLICATIONS have recently been issued by Ransome and Marles Bearing Co. Ltd., of Newark-on-Trent. One is entitled *Ball and Roller Bearings* and is a catalogue of the bearings manufactured by that company. The other is entitled *Design for Bearings*, and it deals with load calculations, manufacture, selection and application. The latter work is well illustrated with half tone and line diagrams, and contains a great deal of information that is of practical use to designers.

S.M.M. & T. Standards

SOME NEW standards and amendments to old ones have recently been issued, by The Society of Motor Manufacturers and Traders Ltd., for incorporation in their book entitled "Standards for the British Automobile Industry". The amended sheets include a new Index, and pages 2-05 and 2-06 of Tyres and Wheels, Section 2 Commercial Vehicles. In addition, the following are the new standards: SMMT 127, Aluminium Alloys for the Motor Industry—Part III; SMMT 93, Lever Type Dampers; SMMT 102, Telescopic Dampers; SMMT 200, Hydraulic Brake Fluid, type 200/1.

The Riley 4/Sixty Eight body has ample glass area and a falling bonnet line. A simple frontal treatment has been adopted

New British Cars

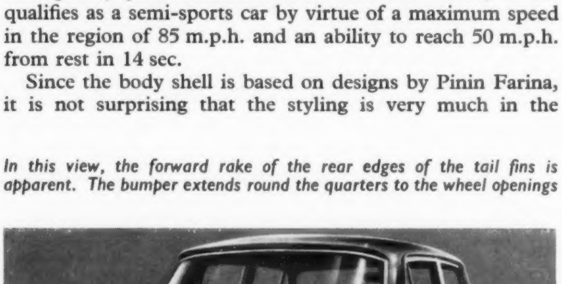
SUMMARY OF THE NOTEWORTHY FEATURES OF RECENTLY INTRODUCED VEHICLES

Riley 4/Sixty Eight

IT is not uncommon for a manufacturer to offer a particular car with alternative sizes of power unit, to increase the range of appeal. In introducing the Riley 4/Sixty Eight, however, the Nuffield Organization has taken the less usual step of reversing that procedure: it now produces two widely different cars of that marque with the same engine. The mildly tuned two-carburettor version of the B.M.C. 1,489 cm³ Series B engine is already fitted to the Riley One-Point-Five, a compact car of high performance but relatively restricted in its accommodation for rear-seat passengers and luggage. In contrast, the similarly powered 4/Sixty Eight has a roominess of the interior and boot that definitely puts it in the family saloon category. While its greater weight and bulk inevitably give the new model a less spritely performance than the One-Point-Five, it still qualifies as a semi-sports car by virtue of a maximum speed in the region of 85 m.p.h. and an ability to reach 50 m.p.h. from rest in 14 sec.

Since the body shell is based on designs by Pinin Farina, it is not surprising that the styling is very much in the current Italian idiom. The appearance is slightly angular, with a shallow roof pressing and ample glass area; both the windscreen and rear light are of the wrap-round type. Other characteristics include a falling bonnet line, that gives excellent forward vision, and tail fins the lines of which begin part way along the rear doors. All four doors have hinged ventilation panels and are fitted with Wilmot-Breeden Zero-torque locks.

In this view, the forward rake of the rear edges of the tail fins is apparent. The bumper extends round the quarters to the wheel openings



To form a definite waistline, a swaging on the side panels extends in a gentle, convex curve from the headlamp cowls to the base of the rear lamp groups. It is emphasized by a narrow, chromium plated beading strip. The traditional Riley radiator is cleverly suggested by the curved V-shape upper edge of the radiator grille and the correspondingly peaked bonnet on which is the diamond-shape name motif. At the bottom, the grille is flanked by horizontal intakes, the barred decoration of which is taken round the sides almost to the wheel openings and incorporates the side and direction indicator lamps.

Orthodox practice is followed in the design of the unitary chassis and body structure, which embodies full-length side members. These, together with the 20 S.W.G. floor, to which they are welded, form box sections; the floor is ribbed and indented for added stiffness. The outer panels of the body are also of 20 S.W.G. steel. At critical points the pressings are united by continuous seam welds, while spot welding is employed elsewhere. Sealing of the joints is carried out where necessary, to prevent dust penetration. The complete assembly is rust proofed by the Rotodip process.

No major changes have been made for some time to the Series B engine, which has a bore of 73 mm and a stroke of 88·9 mm. However, the latest version differs from earlier units in several respects. The lubrication system has been improved by moving the strainer and pump pick-up 2¾ in forward, to avoid loss of pressure during braking and fast cornering. A tendency towards heavy oil consumption at sustained high road-speeds has been cured by increasing the radial pressure of the rings; this has been effected by the use of a stiffer material and by increasing the radial depth from D/26 to D/24. In the interest of long bore life, the top ring is chromium plated. A modification has been necessary to the exhaust manifold, to suit it to both the One-Point-Five and the 4/Sixty Eight installations. The two semi-down-draught S.U. carburettors are of the HD4, diaphragm type,

and are fed by a rear-mounted S.U. PD fuel pump. Connecting the carburettors to the oil-bath air cleaner above the engine is a large-capacity box of cast aluminium. An asbestos lined shield prevents the direct radiation of exhaust manifold heat to the float chambers. On the throttle linkage, the ball housings of the rod joints are nylon mouldings. A gross power output of 66·5 b.h.p. at 5,150 r.p.m. is quoted for the engine, and the maximum gross torque is 85 lb-ft at 3,300 r.p.m.

The four-speed B.M.C. gearbox has synchromesh on second, third and top, and provides internal ratios of 1 : 1, 1·37 : 1, 2·21 : 1, and 3·64 : 1, with 4·76 : 1 for reverse. Gear changing is effected by means of a short, rigid central lever of remote control type. The three-quarter floating live rear axle has a hypoid bevel final reduction of 4·3 : 1, giving 16·53 m.p.h. per 1,000 r.p.m. Semi-elliptic springs of normal design support the body on the axle, and their action is controlled by lever type dampers.

A double wishbone and coil spring layout is employed for the front suspension, the wishbones being of unequal length. Again, lever type dampers are employed. The suspension links and springs are mounted on a massive box-section cross member bolted to the chassis side members. This cross member passes beneath the forward part of the oil sump and, while it protects this from damage, it must also reduce the air flow over it. Unlike the One-Point-Five, which has rack-and-pinion steering gear, the 4/Sixty Eight features a cam and peg gearbox having a ratio of 15 : 1. The 14 in wheels carry tyres of 5·90 in section. A Girling hydraulic braking system is employed, with drums of 9 in diameter; the lining width is $2\frac{1}{2}$ in for the twin-leading front shoes and $1\frac{3}{4}$ in for the leading-and-trailing shoes of the rear brakes.

The interior trim is tastefully arranged, and embodies burr walnut veneer for the facia, instrument panel and door cappings. With the exception of the heater switches and the clock, the instruments and controls are functionally grouped in front of the driver and include a tachometer. Real leather is employed for the upholstery, which is pleated transversely on the cushions and squabs. The individual front seats provide some degree of lateral location for fast cornering, and there is a central folding arm rest for the rear seat passengers. A shock-absorbent underlayer is fitted on the rim of the parcels shelf beneath the facia, and on the upper edge of the facia itself. To avoid reflections, the facia top is covered with matt black plastics material.

With a capacity of 19 ft^3, the boot is unusually large for a $1\frac{1}{2}$-litre car. It is carpeted and is unobstructed by the spare wheel, which is carried in a separate container below the floor. Torsion bars are used to balance the weight of the boot lid. The 10-gallon fuel tank is concealed behind a panel at the front of the boot.

The principal dimensions of the chassis of the 4/Sixty Eight are: wheelbase 8 ft $3\frac{3}{16}$ in, front track 4 ft $0\frac{7}{8}$ in and rear track 4 ft $1\frac{7}{8}$ in. Its body has an overall length, width and height respectively of 14 ft $10\frac{1}{8}$ in, 5 ft $3\frac{1}{2}$ in and 4 ft $11\frac{3}{4}$ in; the turning circle is 37 ft 6 in and the approximate weight $22\frac{1}{4}$ cwt. For comparison, the wheelbase and track dimensions of the One-Point-Five are 7 ft 2 in, 4 ft 2·88 in and 4 ft 2·31 in; its overall measurements are 12 ft 9 in, 5 ft 2 in and 5 ft 0 in, while the turning circle is 34 ft 3 in and the weight is said to be 18·4 cwt.

Triumph Herald

The two-door saloon body of the Herald has a neat, functional appearance, with modest overhang. At the rear, the over-riders blend into the lamp units

FOR a quantity-produced British car, the 948 cm^3 Triumph Herald breaks new ground in having independent rear suspension, in conjunction with an orthodox, forward engine and gearbox installation. A second outstanding feature is the departure from unitary construction, almost universal for small cars nowadays, to a separate, multi-unit body and a chassis of unusual but very functional layout. Ease of maintenance and repair have been given their due importance in the evolution of the design, and it is noteworthy that there are no lubrication points on the chassis. Two body types, each with two doors, are available: a saloon and a sports coupé in which an occasional rear seat is optional. As is the case with the latest Standard Vanguard, the body styling was the work of Giovanni Michelotti, of Vignale, the world-famous Italian specialist coachbuilders. The engine is the familiar and sturdy four-cylinder unit fitted to the Standard Ten and Pennant cars, and has required virtually no alteration to suit the Herald installation.

With regard to the chassis, it was decided that independent rear suspension was necessary if the car was to be as suitable for the rough roads of many overseas countries as for the relatively smooth surfaces of our own roads. The separate construction of chassis and body was adopted because of the considerable cost of any major repairs to unitary structures, this being reflected in the high insurance premiums demanded for cars of that type. Although the view is widely held that the unitary system results in the most favourable strength to weight ratio, it would appear that intelligent design can do much to overcome the basic disadvantage of separate assemblies in that respect. Certainly, the quoted kerb weight of $15\frac{3}{4}$ cwt for the saloon is commendably low, in view of its wheelbase of 7 ft $7\frac{1}{2}$ in, track of 4 ft and comfortable accommodation for four adults. Whereas the track is almost the same as that of the Ten and Pennant, the wheelbase is $7\frac{1}{2}$ in longer.

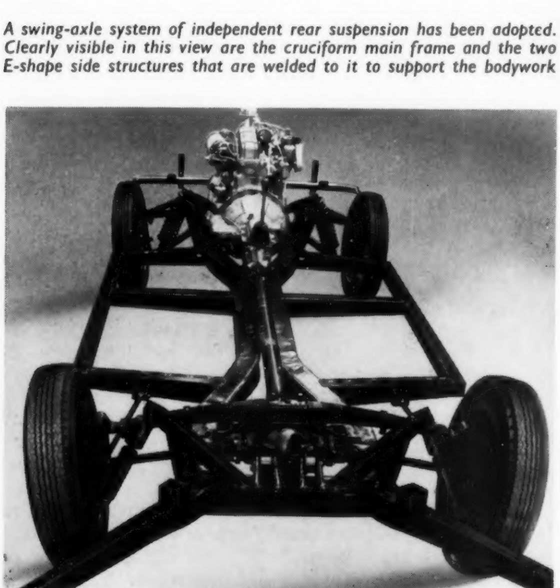
The basis of the all-welded frame is a full-length cruciform

unit comprising two box-section members. Over the middle portion of their length, these members lie close together; they are bridged by short transverse struts, with the propeller shaft above them. Thus, the frame protects the otherwise vulnerable shaft. Towards the front and rear the members splay outwards to embrace the power unit and the rear axle casing respectively. Ahead of the engine and behind the rear axle are box-section cross members. The cruciform members extend forward of the front cross member, and terminate at the robust tube that forms the bumper and carries brackets for the over-riders. At the extreme rear, they are widely splayed to support the rear of the body and to provide a mounting for the rear bumper.

To carry the body, an E-shape structure projects laterally from each side member of the cruciform unit. The middle and rear arms of each of these structures is of box section and the leading one is a channel; all three taper in depth towards the side rail, which is also of channel section. Each front and rear arm lies immediately behind and ahead of its respective wheel. This frame combines low weight with adequate torsional and beam stiffness, and presents an interesting contrast with the Oldsmobile frame illustrated in the article entitled "Current American Cars", elsewhere in this issue of *Automobile Engineer*.

The rear suspension layout is very simple. It is of the swing axle type, with the wheels driven by half-shafts universally jointed to the output shafts of the hypoid bevel final-drive unit. This latter unit is carried by rubber mountings on the rear cross member and an additional cross member ahead of its casing. A transverse, semi-

A swing-axle system of independent rear suspension has been adopted. Clearly visible in this view are the cruciform main frame and the two E-shape side structures that are welded to it to support the bodywork



elliptic leaf spring is bolted directly to the top of the final drive casing, and the wheel hub carriers pivot on pins through the eyes of the spring. Longitudinal location of the wheels is effected by rubber bushed trailing links between the lower ends of the hub carriers and the rear arms of the E-structures. These links also deal with the driving and braking reactions. The upper ends of the laterally inclined telescopic dampers pivot on brackets extending from the rear cross member of the frame.

An orthodox layout of unequal-length wishbone links is employed for the front suspension. To eliminate the need of greasing, rubber bushes are employed for the pivots of the upper links and nylon bushes for those of the lower ones. A ball joint with nylon seat is employed for the upper steering swivel, while the lower one is of the bush type with an integral oil reservoir. The telescopic dampers are accommodated within the coil springs, which are relatively closely wound. At their upper ends, the springs seat in fabricated brackets attached to the side members of the cruciform structure; these brackets also carry the pivot bolts of the upper wishbones. An anti-roll bar, mounted on the underside of each side member, is connected to the forward arm of each of the lower wishbones.

A high standard of driving safety has been aimed at in the design, for which reason rack-and-pinion steering, with its lightness and accuracy of control, has been adopted. The rack unit is positioned ahead of the wishbone assembly. A commendably small turning circle, of 25 ft, has been obtained. Another safety feature of great value, and one of which more is likely to be heard, is the collapsible steering column, designed to telescope at a lower load than that needed to break the spokes of its wheel. The pinion shaft does not extend right up to the steering wheel but is embraced,

The Herald coupé has a curved rear light with a marked forward rake

over the upper part of its length, by a tube to which the wheel is attached. Towards the lower end of the tube there is a short radial slot, having a depth of half the diameter; the upper portion of the shaft is correspondingly milled to a semicircular section. In the slot fits a flat strip that forms part of a split clamp, the other part of which fits round the outside of the tube. The strip transmits the drive from the tube to the shaft; its clamping pressure is adjusted to prevent relative axial movement between the components in normal circumstances, while permitting telescoping under severe impact conditions. Slackening of the clamp bolts enables the distance of the steering wheel from the seat squab to be set as required; the flat on the shaft is long enough to allow 6 in of adjustment, in addition to the collapsing travel needed.

The engine has a bore of 63 mm and a stroke of 76 mm. As fitted to the Herald saloon, it is almost identical with that of the Ten and Pennant cars, and has a compression ratio of 8 : 1, with 7 : 1 optional; a single downdraught Solex carburettor is employed. In this form its net power output is 34·5 b.h.p. at 4,500 r.p.m., and the maximum torque of 575 lb-in occurs at 2,750 r.p.m. For the coupé, two S.U. horizontal carburettors are employed, and the compression ratio is 8·5 : 1. These modifications result in an increase of net output to 42·5 b.h.p. at 5,500 r.p.m.; the torque also is improved to 585 lb-in at 3,000 r.p.m. The four-speed gearbox has synchromesh on the upper three ratios. Because of the higher output and slightly lower weight of the coupé, a final-drive ratio of 4·5 : 1 has been adopted instead of the 4·875 : 1 of the saloon. A short, central remote-control lever actuates the gear change.

Apart from the reduced passenger space on the coupé, and the correspondingly longer boot, both bodies are similar below the waistline. The lines are modern but not exaggerated, and the frontal treatment is simple, with a vertically divided radiator grille and tall over-riders as the prominent features. What appears to be a painted bumper is actually a shroud, or apron attached to the tubular bumper mentioned earlier, and integral with the under-fairing of the front end; similar construction is employed for the rear bumper. An unusual styling feature is the notched profile of the headlamp cowls, as viewed in elevation, matched by a similar notching of the rear edge of the fins, which do not project above the gently convex curve of the waistline but form a continuation of it.

As mentioned earlier, the body is of multi-piece construction, to facilitate repair or replacement in the event of damage. There are actually seven units and three major assemblies: the front wing and bonnet group, which extends to the scuttle; the scuttle and lower portion of the body to about one-third of the way along the door sills; and the rear section, embodying the boot. The first of these assemblies incorporates the wheel arch structure, but not the radiator grille, and pivots upward about its front end to provide clear access to the engine compartment. In the down position, it is secured by two toggle fasteners, recessed into the side panelling.

Both bodies have roof pressings of shallow curvature and, because of the large glass area, the lines of the roof and the quarters are mildly angular. The windscreen and rear light, although curved, have little wrap-round. On the saloon, the rake of the screen is matched by that of the rear light which, however, is more steeply inclined on the coupé. The front-hinged doors are of ample width and their windows embody ventilating panels.

Individual front seats are fitted to both models, and a practical detail of the saloon is that the rear seat squab can be hinged forward to give a large amount of extra luggage space. The upholstery is of p.v.c. leathercloth, and the headlining material is washable. There is a division between the boot and the passenger compartment on the coupé but, where no occasional seat is fitted, there is considerable luggage room behind the front seats. The deep but narrow 7 gallon fuel tank is stowed vertically at the left side of the boot on both models, where it wastes a minimum of space.

Tours of Factories Abroad

A NON-PROFIT organization known as Industrial Travel was started in February to promote inter-factory visits between firms in Great Britain and a number of Continental countries. The organization is a division of Y.T.C. Universal Ltd., the non-profit, travel club that was formed in Liverpool seven years ago to promote international friendship. Covering all branches of industry, Industrial Travel offers comprehensive industrial tours for factory parties, combining suitable holiday activities. The purpose of such visits is to create greater stimulus for the factory worker and to encourage him to be less parochial in his outlook. It is hoped thereby to increase production, cut down labour turnover, augment the interest of employees in their firm, and attract a better type of worker through the indication of a go-ahead policy on the part of the company.

Parties will be under the care of able linguists, so there will be no language difficulties, and they can either visit a number of major factories in their own industry in one country, or can study that industry in all the countries covered by the organization. These countries are Holland, Germany, Switzerland, Italy and Luxembourg. Accommodation can be arranged either in small hotels or *pensions*, or possibly hostels in the case of apprentices. The actual factory tours will be led by officials of the host company, who will be fully qualified to answer technical and other questions. In many instances, the parties will be able to meet employees of the host company in the canteens and sports clubs, or to be taken on sightseeing trips by them. It may even be possible for members of parties to be received into, or even to stay in, the houses of their opposite numbers.

Though the plan of a tour would be arranged to meet individual requirements, a typical one would consist of a week in an industrial area, visiting factories and studying local conditions, followed by a week's relaxation in a holiday or country area. There is already considerable interest in the scheme, not only by managements in this country who wish their employees to visit the Continent, but also by foreign firms desirous of sending parties to this country.

The experience gained by Y.T.C. Universal has proved valuable in the formation of Industrial Travel, and those responsible are certain that, after several years' work, their organization is fully able to fulfil its function. Further information and details of the programmes available can be obtained from the International Secretary, Industrial Travel, Y.T.C. Universal Ltd., 62, Hope Street, Liverpool, 2.

IBCAM Competition

AS IS well known, a Joint Competitions Committee is organized on behalf of the Worshipful Company of Coach Makers and Coach Harness Makers of London, the Society of Motor Manufacturers and Traders, the National Federation of Vehicle Trades, and the Institute of British Carriage and Automobile Manufacturers. The function of this Committee is to stimulate improvements in design of bodywork of private cars and public service vehicles. This year, the annual exhibition of prize-winning drawings and examples of handicraft will be open from 20th to 23rd May in the ground-floor committee room of the Society of Motor Manufacturers and Traders Ltd., Forbes House, Halkin Street, London, S.W.1. Each day, the exhibition will be open to the public from 9.30 a.m. to 1 p.m. and from 2 p.m. until 5.30 p.m. Tickets of admission are not required.

Drawing Pins

A BRITISH STANDARD has been introduced covering draughtsmen's drawing pins. Designated B.S. 1677:1959, it specifies the three sizes—$\frac{1}{2}$, $\frac{3}{4}$ and $\frac{7}{8}$ in—that are generally used. Two types of pin are specified: B.S.1, in which the pin is screwed into the head; and B.S.2, in which the pin is not screwed, but is gripped firmly by swaging or peening.

Copies of B.S. 1677:1959 may be obtained from the British Standards Institution, Sales Branch, 2 Park Street, London, W.1. The price is 3s; postage is charged extra.

Left: The Chevrolet Impala is typical of the latest General Motors convertibles, though the fin design is unique. Applied decoration is not excessive

Below: There is marked variety in the styling treatment of paired headlamps and wheel nave plates. This close-up is of the Dodge Custom Royal hardtop

CURRENT AMERICAN CARS

Trends and Developments Revealed by a Study of the Latest Products now being Distributed in Europe

SURPRISE has been expressed in many quarters that, in general, the latest U.S.A. cars are still longer, lower, wider and more powerful than their predecessors. For the last year or two it has been apparent that the upward spiral of size, weight and performance has been going too far: the cars are costing too much to run, and they occupy too much space, both on the move and when parked. This is not indicative of the manufacturers' ignoring a changing public demand, but is of course due to the inevitable time lag between the initial design and the final production stages. The change in the situation was not foreseen when the current designs were put in hand, and by the time it began to be noticeable, the factories were committed beyond withdrawal. It will be necessary to wait another year or more before the large manufacturers' interpretation of the altered market requirements becomes apparent. The two smaller companies are, of course, already producing compact, functional cars of considerable merit.

One of the most interesting features of the American automobile scene is General Motors' recent change of policy regarding body production. The company has simplified its range to two basic shells for all divisions, with a complete change each year, instead of producing a larger number of shells for a longer period. Thus, General Motors are the only one of the Big Three with entirely new bodies: the Ford and Chrysler groups have had to content themselves with the modification and restyling of their existing bodies.

Bodywork, styling and trim

The four-headlamp layout has now become general, though not universal, and a real endeavour has been made to assimilate the four lamps more happily into the frontal aspect. There are indications, too, of greater efforts to harmonize the styling of the front and rear ends. The latest General Motors cars are probably more successful in this respect than most of their competitors.

In spite of increases in overall dimensions, leg room for the rear seat passengers remains barely adequate on a number of vehicles, though the interior width is vast to European eyes. Interior decoration is perhaps a more suitable term than trim for these cars. Three-tone upholstery and trim panels are

not uncommon; colour schemes are gay and much ingenuity is displayed in the use of a wide range of materials for the purpose. In head linings, also, there is far greater variety than on this side of the Atlantic, and most of the materials used appear to be eminently practicable.

The quantity of stainless bright metal used for exterior decoration is increasing, though on the latest cars, as typified by the General Motors products, the decoration is more restrained than hitherto. Unaesthetically large areas of applied bright metal are still to be found, however, on a number of vehicles. Paint developments have been made that, if they live up to the claims made, are certain to bring praise from all customers. In addition to being more chip resistant, the new finishes are said not to require any waxing for at least the first two years of the vehicle's life, in normal conditions.

There are numerous instances of an increase in glass area, attributable both to the employment of shallow roof pressings and to the deepening of the windscreen: instead of the front of the roof curving down to blend with the windscreen slope, the upper portion of the glass on some of the current cars has a radius to blend it into the roof. This styling certainly gives a clean appearance but it must add considerably to the cost of the screen, both by the increase in area and by the introduction of more complex curvatures. Damage to a screen of this type would entail a heavy bill for replacement. The elimination of the roof peak is certainly beneficial in terms of vision, particularly in hilly country, but it would enhance the greenhouse effect in sunny climates. In contrast to the tendency towards the peakless front, roofs are still in many instances extended beyond the rear window.

The good vision mentioned only applies, however, to dry

conditions; with a deeper screen of more complex curvature, the difficulty of dealing satisfactorily with rain becomes even more pronounced. While there are exceptions, most of the American cars have symmetrically arranged windscreen wipers, with the blades moving in opposite directions. This results, of course, in an unwiped area in the middle of the screen. The wrap-round curvature in most cases is such that there will also be unwiped regions adjacent to the screen pillars. Some radical thinking appears to be necessary if wet-weather visibility is not to become something of an Achilles' heel on these cars. The answer may lie in the provision of more blades, or in a departure from the familiar pivoted action.

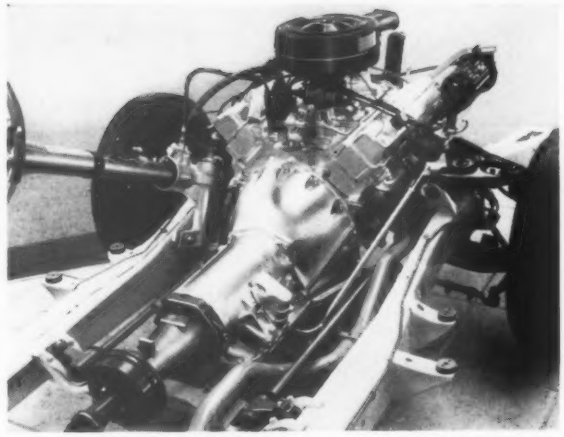
Safety consciousness is manifesting itself in an increasing use of a resilient underlay on the upper rear edge of the facia panel. It is usual to cover the underlay with a matt plastics material, to avoid reflections at night. Rather surprisingly, the lower edges of facias are rarely trimmed in this way, nor are there more than a few examples of flexible or soft-edged sun vizors.

Considerable efforts have been directed at improving seating: the adjustable, reclining squab is popular, and on two-door models the squab is usually divided, with individual control over the halves. Access to the rear seats of a number of two-door bodies is improved by the use of oblique hinge axes for the squab sections. The outboard hinge point is ahead of the inboard point so that the squab tilts inward as well as forward. A more elaborate alternative is the swivelling front seat arrangement offered as an optional extra on various cars from the Chrysler Corporation.

Controls and accessories

The adoption of push buttons has become still more extensive than was the case a year or two ago. They are used for lighting and driving controls, as well as for controlling radio, air conditioning equipment, head retraction on convertibles, and even the automatic transmission settings. A feature of increasing popularity is a group of buttons on the driver's door, to operate all windows; individual buttons are also installed on the other doors. Without the group of push button controls, it would be impossible on such large cars for the driver to vary the degree of window opening on his nearside without stopping the vehicle and moving to the other side of the seat. The other button controls mentioned are in most instances neatly grouped below or alongside the main instrument panel.

Rapid progress continues to be made in respect of heating and air conditioning. Provision is often made for demisting of the rear window, and a Chrysler development is the furnishing of equipment to dehumidify incoming air on cool, damp days, to minimize steaming-up of the windows. Winder operation of the ventilating panels of door windows has been



This view of a Plymouth chassis shows the compact vee-eight engine, power-assisted steering and long torsion bars for the front suspension

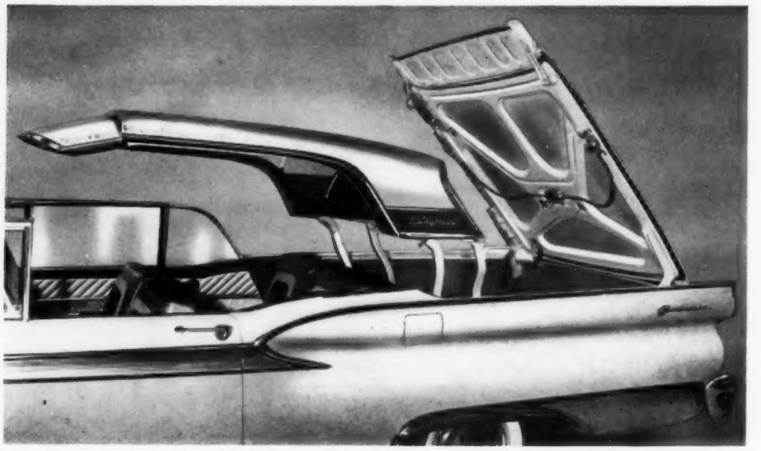
introduced by General Motors, to give precise control and positive positioning. On most other makes, the catches for these panels are of the type on which a button has to be pressed before the catch itself can be undone.

Power units and transmission

The vee-eight layout remains the most popular, but the six-cylinder in-line design continues to find favour as a more economical alternative. Even where the eight-cylinder units are concerned, though, there is strong evidence of a public reaction against high fuel consumption. Although there are several still larger vee-eight engines this year, the shift of emphasis from power output to economy of operation is marked. Lower compression ratios to permit the use of normal premium fuels, smaller carburettors with fewer chokes, and less extreme valve timing are among the methods employed to this end. Such changes will inevitably reduce the very high maximum speeds of which most American cars are capable, but they should result in engines that are more suitable for the road conditions normally encountered. Apart from better economy, higher torque in the middle of the speed range should be obtainable with the lower state of tune. In view of the obscure combustion rumble that has been causing trouble on some of the earlier ultra-high-compression engines, it may well be that certain engine technicians secretly welcomed the changed direction of development.

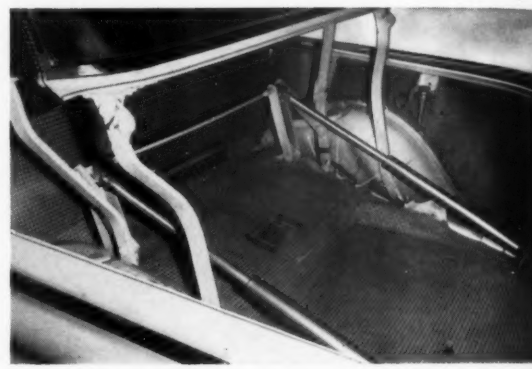
The increased width of the new cars has been utilized to improve air circulation in the engine compartment and

One of the more successful attempts to harmonize the front and rear aspects—the Buick Le Sabre. There are no over-riders on the bumpers



Left: The Ford Fairlane 500 Skyliner has a hardtop head that is retractable into the boot; it is shown here in the mid-way stage. Note the folding front of the head

Below: As would be expected, a complicated mechanism is necessary to retract the head of the Skyliner. This view shows the hydraulic jacks and linkage in the boot



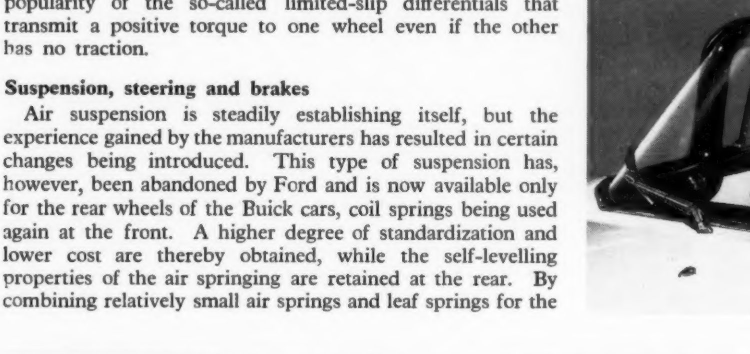
accessibility of the power unit and ancillaries. Corrosion of the exhaust system has become a problem of some magnitude, and it appears to be aggravated by some of the fuel and oil additives now employed. It is being combated in some instances by the use of heavier gauge material, and in others by aluminizing and zinc coating. Several makes have silencers of sandwich construction with an interlayer of asbestos. This not only reduces resonance but, by ensuring the rapid warm-up of the interior surfaces, should reduce the condensation of acidic products of combustion.

Changes to automatic transmission systems have been aimed largely at securing improved efficiency over the normal operating range. On four of the General Motors makes the rear hydraulic pump has been eliminated for this purpose, but as a result, tow or push starting is no longer possible. A new single-range two-speed transmission has been introduced by Ford; it is much simpler than its predecessor and weighs considerably less. There is a marked increase in the popularity of the so-called limited-slip differentials that transmit a positive torque to one wheel even if the other has no traction.

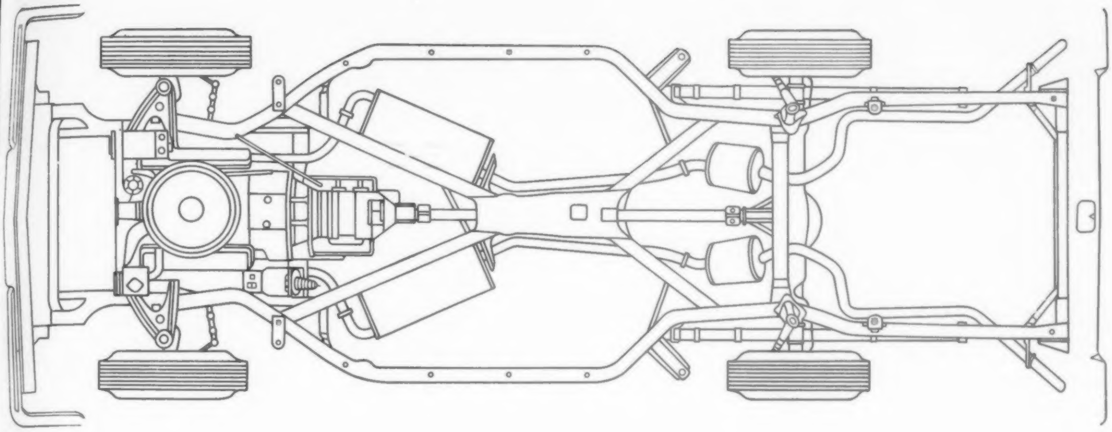
Suspension, steering and brakes

Air suspension is steadily establishing itself, but the experience gained by the manufacturers has resulted in certain changes being introduced. This type of suspension has, however, been abandoned by Ford and is now available only for the rear wheels of the Buick cars, coil springs being used again at the front. A higher degree of standardization and lower cost are thereby obtained, while the self-levelling properties of the air springing are retained at the rear. By combining relatively small air springs and leaf springs for the

Above: The Mercury Monterey is one of the few American cars to have the windscreen wiper blades moving in the same direction



Left: A divided frontal grille, with an auxiliary intake under the main portion of the bumper, is found on the Pontiac Laurentian. The windscreen is very deep



Above: Plan view of the Oldsmobile frame, the only one to have side members and a cruciform member for torsional stiffness. The dual exhaust system is long and complex

Right: The only real sports car made in quantity in the U.S.A. is the Chevrolet Corvette. Glass-reinforced polyester resin is used for the body and the hard top

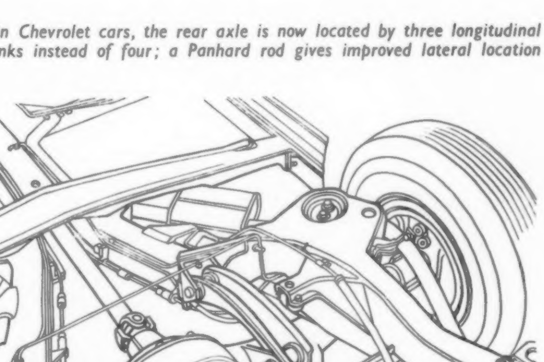
rear axle, Chrysler has effected a compromise that is said to be very effective. Self-levelling suspension not only compensates for variations in static load, but with certain arrangements it also obviates large variations in attitude during sustained braking and acceleration that are otherwise encountered with soft suspension. The acceleration aspect is particularly important in view of the high power : weight ratio of many American cars.

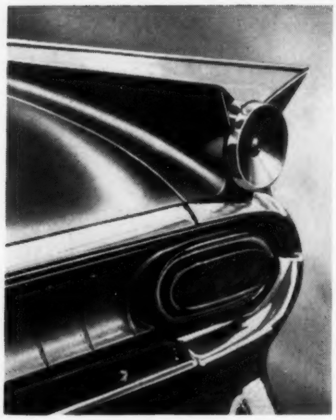
An interesting damper development, so far found only on Cadillac cars, is the use of a hollow gas-filled annulus of flexible plastics to compensate for the volume variation that occurs during the working stroke. As is well known, the variation results from the displacement of fluid by the piston rod, and it tends to give rise to aeration of the damping fluid as air is drawn in during the outward stroke of the piston. The plastics annulus is in the recuperation chamber; it expands as the piston moves outward and contracts on the inward stroke, to make room for the fluid displaced by the piston rod. Thus, no air is drawn in and therefore aeration cannot occur.

In 1957, the number of new cars sold with power-assisted steering was under 28 per cent, whereas last year the figure rose to about 46 per cent. It thus seems likely that the total for the current year will comfortably exceed 50 per cent. Development has been directed mainly towards obtaining more rapid response, but reduced effort and greater self-centring effect have been other objectives. In the earlier days of powered steering, no attempt was made to raise the gear ratio used, because there was thought to be a danger of over-violent reactions by drivers accustomed to considerable wheel winding, also because of the high effort needed in the event of power failure. There is now an indication that the disadvantages of a very low ratio are becoming appreciated, as evidenced by instances of smaller reductions in the steering box. In one case, the number of steering wheel turns from lock to lock has been reduced from $4\frac{1}{3}$ to $3\frac{2}{3}$, a change which should result in greater controllability.

So far as brakes are concerned, with the virtual standardization recently of the 14 in wheel, a 12 in diameter drum has become too tight a fit within the rim for good cooling. Though some American firms have been reluctant to reduce the diameter of their brakes, those who have changed to an 11 in drum have, in most cases, also improved the stopping

On Chevrolet cars, the rear axle is now located by three longitudinal links instead of four; a Panhard rod gives improved lateral location





A Pontiac detail is the duplication of the tail fins. The second fin inclines inward to form a vee with the main, outer fin

power and resistance to fade. For these benefits, wider drums, with greater lining area, and better air circulation are largely responsible. In some cases the drums have been moved inboard from the wheels, to expose more of them to the air stream, and use is also made of large flanges on the drums, thereby increasing the surface area for heat dissipation. Automatic adjustment for wear is popular, there is a tendency for lining thickness to increase, in the interest of less frequent renewal, and servo assistance is available on numerous models.

Frame construction

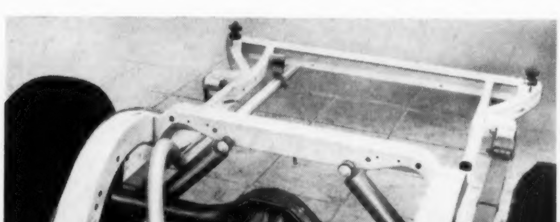
To get the desired low roof line, many American cars have a step-down floor, below the level of the door sills, and the necessity of providing an adequate level floor width has set the chassis designers a difficult problem. One solution might be to employ unitary construction but, while this is satisfactory for smaller cars like the Rambler, it is much less so for the larger vehicles: because of the large glass area, the tie between the upper portions of the two sides is not strong, so that considerable bracing at floor level is needed and weight is consequently high. Nevertheless, this construction is used by Ford on the Lincoln and Thunderbird models; the latter is admittedly a relatively compact two-door vehicle, without quarter lights.

Where a separate chassis frame is used, there are two common basic designs: one has side members, and the other is a cruciform structure without these members. In the second type, the body is supported on long outriggers, with the result that the overall body-chassis stiffness tends to be inadequate and scuttle shake is difficult to avoid. Those frames of the first type on which a step-down floor is featured have a considerable outward bow of the side members to clear the passenger compartment. With this layout it is not easy to incorporate a central cruciform bracing member, only Oldsmobile having succeeded in this respect. Without such a member, the bowed frames are rather lacking in torsional rigidity. On the Chrysler Corporation products, the flat floor above the side members is retained. These members can therefore be nearly straight in plan view, with consequently greater resistance to torsion.

Increasing attention is being paid to sound deadening and the elimination of resonance. The main areas where insulation is applied are to the floor, beneath the carpet, to the inner surface of the roof pressing, to the scuttle and to the underside of the bonnet and boot lid. A wide variety of materials is used, including bituminized felt, glass fibre and polyurethane foam; the sections are normally stuck to the panels, but on some bonnets and boot lids the material is sandwiched between the main and inner pressings.

In the subsequent sections of this review, the individual makes will be studied in greater detail. To round off the general survey, however, mention must be made of a styling feature that is used far more in the U.S.A. than in Europe, namely the wheel nave plates. Real efforts have been made during the last year or two to give these components individuality and, to some extent, harmony with the rest of

Below: Left, the rear shock absorbers of the Plymouth are considerably inclined to the vertical; right, the oblique hinge axis of the Mercury divided front squab provides easier access to the rear seat. Above: Another method of facilitating access is the Plymouth pivoted front seat layout



This Plymouth model typifies the American approach to the station wagon design. The stowage space available is considerable and the overall dimensions approximate to those of the normal saloons in the range

In contrast to the Plymouth, the new Studebaker Lark station wagon is of modest dimensions and its wheelbase is only 9 ft 5 in. Little use is made of applied decoration on the exterior

the vehicle. While the results are, in some instances, over-elaborate to our eyes and certainly difficult to clean, other examples are aesthetically satisfactory, both on their own and in their context. All are indicative of the thoroughness of the American approach to automobile styling.

American Motors Corporation

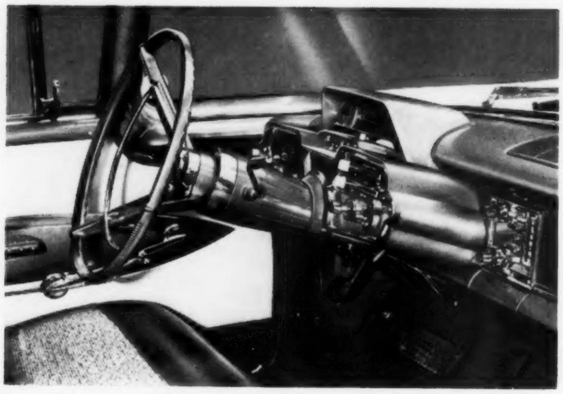
The relatively small, Rambler unitary construction cars sold very well during 1958, and only minor changes have been found necessary. Made as an inexpensive saloon and a station wagon, the Rambler American is a simple, unadorned vehicle with a wheelbase of only 8 ft 4 in and restricted overhang. The windscreen and rear light are not of the wrap-round type, there are two headlamps and the interior trim is simple. These models are powered by the old 196 in^3 six-cylinder side-valve engine, rated at a mere 90 b.h.p. and available with a normal gearbox or Borg-Warner automatic transmission.

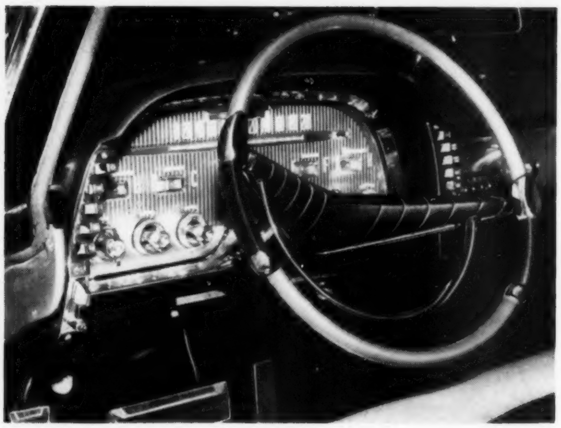
Among the few changes to the station wagon version is a lowering of the roof line. This model has two wide doors, and divided windows on each side of the rear passengers' seat; the portions of glass overlap in the middle and each can be slid longitudinally to adjust the ventilation. The rear door is divided horizontally below the slightly curved rear light. At first glance, the head lining of this range looks like a woven material but it is actually plastics sheeting embossed to resemble the weave. In spite of their compact dimensions, the Rambler Americans are certainly not inferior in leg and headroom to many of the much larger U.S.A. products, though naturally they have not the same seating width.

More elaborate, but still restrained, economical and relatively inexpensive are the Rambler models with a wheelbase of 9 ft and an overall length, in saloon form, of under 16 ft. They are available with either a six-cylinder or a vee-eight engine; the former is an overhead-valve version of the 196 in^3 unit, and the other is a 250 in^3 engine of 215 b.h.p. Air suspension and power-assisted steering and brakes are among the optional equipment available.

The Ramblers have four headlamps, wrap-round windscreens and rear lights, and prominent tail fins, with trailing edges that are notched, as viewed in side elevation. Bright aluminium, with a fluted finish, is used for the window surrounds on the saloons and station wagon. Two-tone and three-tone upholstery and door trim is available. An unusual feature of the station wagon is the bottom-hinged rear door,

The Studebaker Lark is available with either a six-cylinder or a vee-eight engine; the installation of the latter unit is rather crowded





the scale, only Chrysler fits the largest; engines of the remaining three capacities are used by other divisions of the Corporation.

For the Chrysler Imperial, an interesting shock-absorbent propeller shaft has been evolved: it is shown in one of the accompanying illustrations. Other improvements of the mechanical components used by the Corporation include torsion bars of reduced length and diameter, and a simple and positive cam type device for adjustment of camber and castor angles. The supplementing of the rear leaf springs by air springs has already been mentioned. These air springs are quite small and are of the rolling diaphragm design; they are connected to a common surge tank set transversely above the rear axle. There is a single levelling valve, an arrangement which provides less resistance to body roll than does the use of two valves, but also minimizes the excessive roll that occurs after going from one lock to the other, during the time lag of the valve. About 20 per cent of the sprung weight is carried by the air springs, which have a normal working pressure of 20 to 30 lb/in^2, by no means a high figure.

Above left: The tiered instrument panel and deeply dished steering wheel of the Mercury cars. Left: On the Chrysler Imperial, the grouped instruments are flanked by push buttons. Below: The bonnet of the Ford Thunderbird has a sandwich layer of sound-deadening material and, unusually, is hinged at the front

which cannot be opened until its window is wound down clear of its guide channels in the body. The window handle is external and can be locked. On these models, the rear compartment is obviously an addition to the standard saloon body shell, and the lines of roof, side lights and tail fins can hardly be regarded as harmonious.

Completing the American Motors range are the Ambassador models, with a wheelbase of 9 ft 9 in, an overall length of 16 ft 8 in and a 327 in^3 vee-eight engine developing 270 b.h.p.. These cars are similarly styled to the Ramblers and, though appreciably longer, are still small by American standards. On both the Rambler and Ambassador series, individual front seats have been introduced as an optional extra.

Chrysler Corporation

After being in production for eight years, the Chrysler Firepower vee-eight engines, with their part-spherical combustion chamber design, have been superseded by units having wedge shape chambers and parallel valves. The change has been made to save a considerable amount of weight and to cheapen production costs. The new engines are made in two basic forms: of these, the larger has a swept volume of 361, 383, or 413 in^3, while the smaller is available in sizes of 318 and 326 in^3. According to carburettor arrangements and cams, power outputs range from 230 b.h.p. for the 318 in^3 standard unit to 380 b.h.p. in the case of the 413 in^3 engine with two four-choke carburettors, a special camshaft and dual exhausts. Dodge and Plymouth continue to offer their well tried six-cylinder engines, of 135 and 132 b.h.p. output respectively, on the lower priced cars. Only the latter firm lists the smallest vee-eight unit and, at the other end of

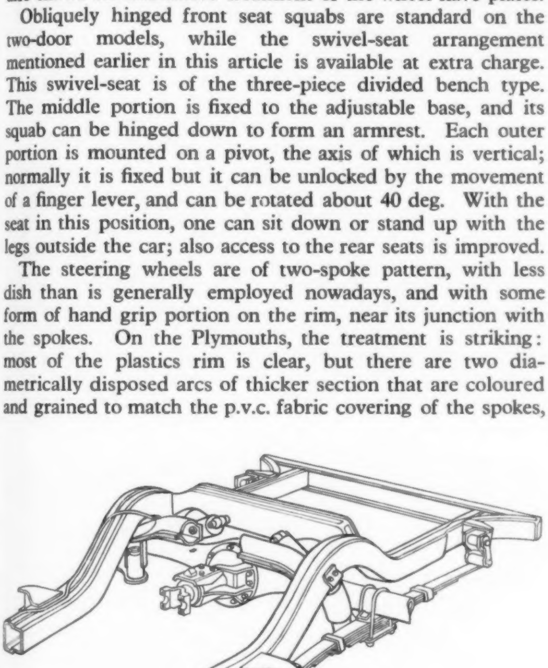
On all models the windscreen pillars have a rearward slope and therefore do not have to be cranked so much as those on certain other makes, to accommodate the wrap-round screen. Thus, the pillars are stronger and there is less obstruction to entrance and exit. A shallower roof pressing than hitherto is featured on some models, and the correspondingly deeper windscreen is curved in elevation to blend into the leading edge of the roof. Frontal treatment has been modified and the lower mounting of the headlamps on the Chrysler cars leaves a rather unsightly gap between the lamps and the flat peak above them. The DeSoto models have a similar peak, whereas on the Plymouths an undulating eyebrow type of cowl is employed. More pleasing is the large-radius cowl on the Dodge models; outboard of the lamps this sweeps downward and rearward to a decorative strip over the front wheel opening. However, the neat effect is rather marred by the bulky, deeply fluted housings for the parking and indicator lamps at the ends of the radiator grille. These

An Oldsmobile characteristic is the widely spaced headlamps, with the parking lamps between them. The rear lamp groups are housed in elongated nacelles

features are clearly revealed in one of the illustrations, which also shows the decorative treatment of the wheel nave plates.

Obliquely hinged front seat squabs are standard on the two-door models, while the swivel-seat arrangement mentioned earlier in this article is available at extra charge. This swivel-seat is of the three-piece divided bench type. The middle portion is fixed to the adjustable base, and its squab can be hinged down to form an armrest. Each outer portion is mounted on a pivot, the axis of which is vertical; normally it is fixed but it can be unlocked by the movement of a finger lever, and can be rotated about 40 deg. With the seat in this position, one can sit down or stand up with the legs outside the car; also access to the rear seats is improved.

The steering wheels are of two-spoke pattern, with less dish than is generally employed nowadays, and with some form of hand grip portion on the rim, near its junction with the spokes. On the Plymouths, the treatment is striking: most of the plastics rim is clear, but there are two diametrically disposed arcs of thicker section that are coloured and grained to match the p.v.c. fabric covering of the spokes,



into which they blend. The upper edges of facias carry a resilient roll under matt plastics fabric.

Automatic headlamp dipping is available on certain models and an ingenious Chrysler optional feature is a self-dimming mirror. The latter device is operated by a photo-electric cell, sensitive to light from the rear, used in conjunction with an amplifier and solenoid assembly. Although it is something of a gimmick, it could undoubtedly be of benefit not only for busy main road conditions out of town, but also for town driving, where side lamps are not regarded as adequate and dipped headlamp beams are obligatory.

Woven fabric head linings are still employed on certain of the lowest priced cars, but most vehicles are equipped with linings of various plastics materials. On the Chrysler Windsor hardtop, for example, the flexible sheeting has fine perforations, giving a polka dot effect. The seams and listings are concealed by transverse strips of chromium plated metal. Even more unusual is the lining arrangement of the Dodge Custom Royal four-door hardtop and the Plymouth station wagon. It comprises single-curvature sections of rigid laminated-plastics sheet, which is perforated in the same manner as the flexible sheet just mentioned, and secured by transverse bars of moulded plastics.

Ford Motor Company

For economy rather than for performance, Ford continues to manufacture the familiar 223 in^3 six-cylinder engine, available on both the Edsel and the Ford ranges. In addition there are the normal 292 and 332 in^3 vee-eight units, the larger of which is also offered in the Edsel cars in 361 in^3 form and rated at 303 b.h.p. In the Ford range, the existing 352 in^3 high-performance engine, with a four-choke carburettor, is still employed and, like the others, has a slightly reduced compression ratio to enable it to run on normal premium-grade fuels. The Lincoln and Continental models are fitted with a 430 in^3 vee-eight unit producing 350 b.h.p. This engine is now available on the Ford Thunderbird, and is also featured on the Mercury range both in that size and as a 383 in^3 unit; the standard Mercury engine, however, is a 312 in^3 vee-eight unit of 212 b.h.p.

The new Ford single-range, two-speed automatic transmission was referred to earlier, and marks a complete departure from the recent trend towards more speeds and greater complexity. Partly because of the use of aluminium instead of cast iron for the casing, the new transmission unit weighs 50 lb less than its three-speed predecessor; it also contains 105 fewer parts. This transmission is offered, with the

Left: A combined air and leaf spring suspension is now available on Chrysler models. Below: On Ford four-door hardtops and convertibles a reinforcing pillar projects appreciably into the rear passengers' space

The Rambler American station wagon was introduced earlier than the Studebaker Lark model depicted on a previous page, but is of similar design, with a short wheelbase and a simple but practical specification

option of the existing two-range system, on the Ford and Edsel models. A differential of the limited-slip type is fitted by Ford, Edsel and Lincoln, to improve traction in slippery conditions.

There has been general attention to the exhaust system, to reduce corrosion troubles, and silencers are made from aluminized steel, with a double-wall construction and an asbestos interlayer. Body insulation has also been improved, mainly with a view to reducing the noise level. However, the enhanced insulation of the dash on the latest Lincoln cars, by the addition of an aluminium layer over the glass-fibre, facilitates the cooling of the interior in hot weather by the air conditioning equipment.

An earlier reference was made to the deletion of air suspension from the specification of all ranges in the company. The significance of this is not yet clear: perhaps an improved and, possibly, cheaper system is being developed but is not yet at the production stage. The Edsel and Mercury front suspension layouts have modified geometry to allow the use of lower-rate springs without loss of resistance to nose dip on braking. At the rear, the suspension systems have also been given a softer action; in addition, the track of the Mercury range has been increased, while the adjustment of castor and camber angles has been simplified.

With the manually controlled transmission, the rear suspension of the semi-sporting two-door Thunderbird coupé, in its original form with splayed trailing arms and coil springs, permitted some axle hop in first and reverse gears. Additional locating links were tried without success, so the design has been completely changed. Leaf springs are now used, with the axle mounted appreciably ahead of the middle of the springs. The brake lining area of the Lincoln cars has been increased by no less than 44 per cent, and a considerable increase has been effected on the Mercury range also.

Both the Ford and the Mercury bodies are increased in length; these increases amount to no less than 6 in on the Ford Custom 300 and 5 in on the station wagon, which has an additional 11 ft^3 of load space. The Mercury models now have possibly the deepest and most steeply raked screens of any American cars, and their styling has noticeably improved over the last two years. However, the same can hardly be said of most of the Ford range: the absence of new body shells has brought recourse to some rather unhappy redecoration, both internal and external. The sides of most models are trimmed with considerable areas of fluted bright metal, and the merging of the plated fin capping with the side flashes is clumsy.

Originally a two-seater sports model, the Thunderbird has been developed into a close-coupled four-seater and in that form is proving very popular. Though rather over-sculptured, the sides of this model have little applied decoration; the front bumper embraces the radiator grille but the assembly looks curiously detached from the rest of the car. The dipping bonnet line between the paired head-lamps is matched by a down-curving channel in the boot lid, flanked by two large pairs of rear-lamp units. A similar boot treatment is found on the Edsel Corsair, but with smaller, triple lamp units; in this instance, however, the bonnet has a central ridge instead of the dip.

In contrast with the side-by-side headlamps of the Ford, Edsel and Mercury products, Lincoln employs a diagonal arrangement of the lamps, with the planes through the lamp axes inclined outwards at about 50 deg to the horizontal.

On many American cars, the capacity of the boot is restricted by the spare wheel, as in the Edsel, right, and the Ambassador shown below

A very wide grille and a massive two-tier bumper are featured. As on the Thunderbird, the sides of the Lincoln models are boldly sculptured and there is an attempt to match the styling of the rear end to that of the front, but this is marred by over-elaboration. As already stated, the Lincoln models have a unitary chassis-body construction, and the makers claim that the torsional rigidity of the latest structures is 35 per cent higher than that of their predecessors.

Nearly flat rear lights are found on a number of hardtops from the Ford group, including the Thunderbird, the Galaxy version of the Fairlane 500 and the Continental. In this last instance, the window has a reverse slope and its mid-portion retracts behind the rear seat. Another body that has the shallow-curvature rear light is the fantastic Fairlane 500 Skyliner which can be described as a hardtop convertible. When the push button control is operated, the complete hardtop stows itself in the enormous boot. A complicated system of hydraulic jacks, electric motors and mechanical linkages provides the ingenious motions involved.

Above right: The steering wheel rim of the Plymouth Belvedere is largely of clear plastics material. Very small ventilating panels are fitted to the doors

Right: Now a four-seat coupé, the Ford Thunderbird retains its sporting character. Below can be seen the nearly flat rear light and the large, paired rear lamps that are featured on this car

Part of the complexity results from the necessity of having a hinged portion on both the head and the boot lid: that on the head shortens this component sufficiently to enable it to fit into the boot, whereas that on the lid opens as the head is stowed, to lengthen the panel to fill the gap behind the rear seat. One cannot but applaud the technical enterprise of this design, while pondering the effects of any unreliability in the actuating system.

On most models, the interior trim is lavish and, in some cases, verging on the ornate. Three-colour schemes are available, such as red, white and blue or black, white and olive-bronze. Doors are ornamented by sections of metal foil or metallized plastics sheet, with fine checker-board patterns. The higher-price models have padded edges to the facias, and a Mercury feature is soft rolls behind the upper edges of the front seat squabs. Hinges with their axes obliquely arranged are employed on the divided squabs of the convertibles.

The Thunderbird not only is one of the few cars to have really flexible vizors, but also both sections of its divided facia have soft edges. In spite of its change of character, this car retains a functional and largely European style interior, with separate front seats. The transmission tunnel is deep, of square section and neatly trimmed; on it are mounted the heating system controls, window push buttons and ashtrays, all accessible and attractively disposed. On this model, the head lining is of perforated plastics sheet, while other materials used for this purpose by the company include fluffy cloth, and plastics fabrics with a dimpled or a polka dot finish.

General Motors Corporation

As hitherto, there is no attempt to make any particular engine common to more than one division of the Corporation. Buick continues to produce two vee-eight units, the smaller unchanged in swept volume, at 364 in^3; the larger has been increased in size to 401 in^3 and, with a four-choke carburettor, produces 325 b.h.p. Longer connecting rods are employed than on the earlier engine. The swept volume of the Cadillac unit, too, has been raised by lengthening the stroke, from 365 to 390 in^3. Nevertheless, the use of a more efficient combustion chamber design, a modified camshaft and improved manifold heating is claimed to have given the new engine an advantage of 10 per cent reduction in fuel consumption relative to last year's version.

In the search for better fuel consumption, the Chevrolet

Left: The foamed plastics head lining of the Chevrolet Corvette hardtop. The Mercury Monterey, on the right, has a three-peak frontal profile

235 in^3 six-cylinder engine has been fitted with a modified camshaft that drops the maximum power from 145 to 135 b.h.p., though it results in better torque at lower speeds. This division also builds two vee-eight units, one of 283 in^3 and the other of 348 in^3. In its lowest state of tune, for economy purposes, the smaller engine develops 185 b.h.p., but at the other end of the scale is the highly tuned variant installed in the Corvette sports model: this is reputed to produce 290 b.h.p. at 6,200 r.p.m. The larger power unit has an inclined head and block joint face, and its output ranges from 250 to 315 b.h.p., according to the degree of tune.

Although basically eleven years old, the Oldsmobile vee-eight engine is still doing well in the face of competition In its latest form it has a swept volume of 394 in^3, as against its previous 371 in^3, and the crankshaft journal diameters have been increased. A carburettor improvement permits a fast idle to be retained to prevent stalling after the automatic choke has cut out of action. The new engine has a lower compression ratio than before and develops 315 b.h.p. with a four-choke carburettor fitted. If greater economy is desired, the 371 in^3 engine is still available, with a two-choke carburettor.

Pontiac also has only one basic vee-eight engine, further increased in size from 370 to 389 in^3, and now fitted with a cast crankshaft having greater journal diameters. There is a considerable range of compression ratios, carburettors and other features, so that outputs vary from 215 b.h.p. up to 345 b.h.p. In the latter case, the specification includes three two-choke carburettors, a 10·5 : 1 compression ratio and a special camshaft and exhaust system. The economy version, on the other hand, has the relatively low compression ratio of 8·6 : 1, a two-choke carburettor of moderate size and a camshaft providing a smaller overlap than hitherto.

Transmission developments by General Motors include new triple-turbine automatic units available as optional equipment on Buick and Chevrolet. Cadillac, Oldsmobile and Pontiac continue to list the Hydra-Matic transmission, but with the rear hydraulic pump eliminated, as mentioned earlier. This same modification has been made to the Buick automatic transmissions; this division has adopted a limited-slip differential, also an optional extra.

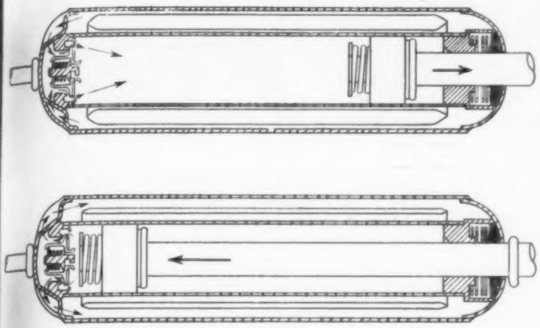
Among the chassis changes, the 5 in increase in the track of the Pontiac cars must be noted, and the frame stiffness has been increased accordingly. This greater width has improved cornering stability and has resulted in a roomier interior to the bodies. The Buick frame, with its bowed, box-section side members, has been increased in width, as has that of the Oldsmobiles, the only frame with side members that embodies cruciform bracing. Handling of the Buick models has been improved by modifications to the suspension geometry, to raise the roll centre heights at the front and rear.

Reference has already been made to the option of air suspension on the rear wheels only in the Buick range. The pneumatic system forms virtually a closed circuit, with no loss of air so long as the compressor is running. A very low rate is provided by the air springs at about the static load deflection, and the upward travel of the wheels has been increased to 5 in. Spring rates have been lowered on the air suspension systems available on Cadillac and Chevrolet cars. Previously, Chevrolet utilized a four-link system of locating the rear axle laterally and longitudinally, but this layout has been modified to give better stability and roll-steer characteristics. The two upper links have been replaced by a single link, and a Panhard rod now relieves the links of lateral loading.

For some time, Buick has featured aluminium cooling jackets on the front brake drums. These are retained but the liners are now bonded in, instead of being a press fit with dowel retention. Axial finning is employed on the rear drums to improve heat dissipation. On the Chevrolet Corvette, a change has been made to multi-segment brake linings of sintered metal; these linings are claimed to have a high resistance to fade and to be immune to adverse effects of water. Though their own life is long, their effect on drum life is not divulged. The other Chevrolet models, and the Oldsmobiles and Pontiacs, have wider linings. Each make has a different method of improving the cooling of the 11 in diameter drums: Chevrolet employs slotted wheels to give air circulation over the drums; Oldsmobile fits a very large flange to the drum, giving an increased surface area of 88 in^2; while Pontiac having adopted a wider track has moved the drums inboard from the wheels.

The fact that the General Motors body shells are entirely new is obvious when they are compared with those of other makers. They are long and low, with flat roofs, plenty of window area and deep, well raked windscreens of double curvature. Frontal overhang is reduced, whereas that at the rear is extended, and the decoration applied to the exteriors is noticeably more restrained than before.

Within the basic form imposed by the body shells, there is an interesting variety of styling, notably in respect of the treatment of the front and rear ends. For harmony of the extremities, the latest Buick models are the most pleasing. the high-shouldered look of the front, with its inclined pairing of the headlamps, being matched by the dihedral of the rear fins above the large—but not over-large—rear lamp groups. From above the headlamps, the shoulder moulding sweeps gently down along the sides, terminating on the axis of the rear lamp. The frontal parking and indicator lamp



Above: A new type of suspension damper is employed on Cadillac cars: it embodies a gas-filled, flexible annulus to compensate for the volume variation during the stroke

Above right: The Lincoln bumper is very deep, with over-riders at the extremities, and the headlamps are obliquely disposed

Right: Excessive decoration of the body sides with applied bright metal detracts from the lines of the Ford Fairlane 500

groups are long and the bumpers are of simple form.

Perhaps more spectacular are the flared, gull-wing fins of the Chevrolets; the outer edges of these fins are virtually horizontal. However, the rear lamp treatment is less successful and gives the rear view a faintly reptilian aspect. The headlamps are mounted side by side, lower than on the Buick, and are surmounted by a pair of secondary air inlets with the side lamps in their extremities.

Oldsmobile and Pontiac both have adopted strongly accented horizontal styling at the front of their cars, but the treatment of each is quite different. On the Oldsmobile models the headlamps of each pair are separated by the side lamps, on a continuous grille. A centrally divided grille is favoured by Pontiac, with the paired lamps close together at the ends; the side lamps are sited below the main portion of the bumper. This manufacturer provides a variation on the tail fin theme by means of a second, inwardly inclined fin making a vee with the main fin. The high fins deliberately retained by Cadillac do not seem to suit the lines of the new bodies, nor do the ornate, spiked front and rear grilles. On the Oldsmobiles, in contrast, the term fin can hardly be applied, because the upward projections are in fact nacelles for the rear lamps, and their line is carried forward to the front wings.

The interiors of these models are brightly furnished but with less obvious striving for effect than on some other cars. Woven and plastics sheet materials are employed for upholstery and trim, some of the woven fabrics embody metallic thread, and three-tone schemes are found on all save the least expensive models. On the Buick Le Sabre hardtop and Chevrolet Impala convertible, the floor is covered in a p.v.c. coated material having a rather knobbly surface, apparently intended to simulate the carpet used on other models. The oblique arrangement of the hinge axes has been adopted on the front seat divided squabs of hardtop and convertible models.

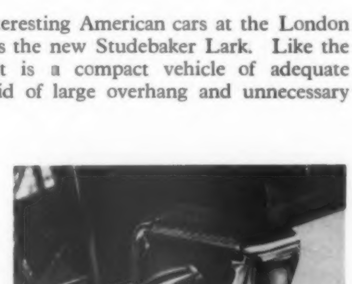
Unusual head linings are found on the Chevrolet Corvette and on the Oldsmobile Super 88 four-door hardtop. The Corvette body is, of course, largely built of glass-reinforced polyester resin, as is its detachable hardtop. In this car, the head lining is a moulding in foamed plastics, perhaps ½ in thick and with a smooth skin. It has an indented grille pattern moulded in, and is stuck directly to the roof. The Oldsmobile lining is also of foamed plastics but the finely fluted surface is unsealed. It is not stuck on but is held up to the glass fibre interlining by transverse strips of bright metal.

Shock absorbent padding is fitted to the upper edges of all the facias, below the matt plastics covering. Except on the low-price Chevrolet Bel Air saloon, the glass of each side light is controlled by a push button; in addition to individual buttons on the doors, there is a group on the driver's door, for remote control. The ventilating panels are operated by winders, except on the Bel Air which has winders for the windows and a catch with a push button type release for each panel, as an anti-theft precaution.

Studebaker

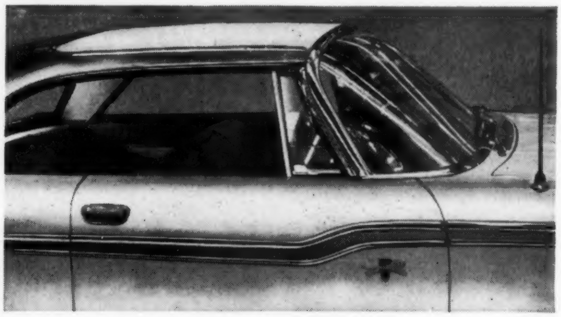
One of the more interesting American cars at the London Show last October was the new Studebaker Lark. Like the Rambler American, it is a compact vehicle of adequate seating capacity, devoid of large overhang and unnecessary

An item of additional equipment on Ford cars is this neat design of exterior rear-view mirror



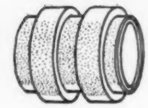
decoration, and intended to appeal to the same market. Because of its better appearance, it may well prove even more successful than the American, and it certainly has greater export potentiality than have the current products of the Big Three.

The standard engine of the Lark is a 170 in^3 side-valve six-cylinder unit of 90 b.h.p., but there is the option of a vee-eight engine of 180 b.h.p. Although the six-cylinder unit has the same swept volume as hitherto, it is in fact new

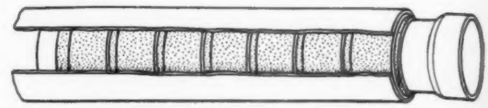


The Chrysler Windsor has a deeper windscreen than before; the roof treatment and the cranked waistline are aesthetically conflicting

and has a shorter stroke, a stiffer crankshaft and improved combustion chamber design; the compression ratio is 8·3 : 1. A normal gearbox, with or without overdrive, and the Borg-Warner automatic system are the alternative transmissions available, and a limited-slip differential is offered at extra charge. The wheelbase of the saloon is 9 ft 0½ in, its overall length is 14 ft 7 in and its weight, with the six-



A resilient propeller shaft is fitted to the Chrysler Imperial. The rubber rings are bonded to the inner tube of the assembly and are compressed into the outer tube



cylinder engine, is little over 22 cwt. At least 25 m.p.g. is claimed for this version.

A handsome station wagon on a 9 ft 5 in wheelbase has joined the two-door and four-door saloons, which follow generally similar lines. All three models have twin headlamps and simply styled bumpers. The lid of the boot is balanced and, though the container is quite large by European standards, the presence of the spare wheel on the floor reduces its capacity appreciably. Also, the top edge of the skirt panel is well above bumper level, so that a considerable lift is needed to get items in or out. Interior features include a simple instrument panel, a two-colour steering wheel, safety rolls at the bottom as well as the top of the facia, and the use of metallized plastics material for part of the door trim, which is applied over a resilient backing.

The Studebaker-Packard group has been in financial difficulty for some time, and it is looking mainly to the Lark to restore its fortunes. Production economies include the complete dropping of the luxury Packard range and the reduction of the range of Hawk sports coupés to one model, the Silver Hawk. Its basic lines are little changed from Raymond Loewy's brilliant design of the early post-war years, and it is offered with the same engines as is the Lark.

Cawkell Storage Oscilloscope

AN improved storage oscilloscope is to be produced by Cawkell Research and Electronics Ltd., Scotts Road, Southall, Middlesex. Known as the Remscope, the new equipment embodies the English Electric E702 storage and display cathode-ray tube, which has a much quicker response than the American Memotron tube fitted to earlier Cawkell oscilloscopes of this type. The E702 tube contains a storage system that enables a transient to be stored for up to 7 days and displayed for a limited time during that week. This display time, which may be divided or continuous, is at least 15 minutes and may, on all but the fastest signals, be extended to nearly two hours, though with slight reduction in brightness. The display may be left switched off until required, so that only storage is taking place, or it may be switched on automatically when a signal is received.

To enable one event from a series to be compared with its predecessor, the persistence of the display can be varied from a few seconds up to 15 minutes. For example, by adjusting the persistence the first signal can be made to fade as the third appears, and so on. Erasure of the signal is rapid and can be obtained by pressing a button on the control panel or by making an external circuit. An external erasing timer, to allow a signal to be removed after a pre-set interval, will be available.

Either A.C. or D.C. current may be used to start the time base of the oscilloscope, and starting is automatic once the input potential exceeds a pre-set level. The time base covers a wide range of velocities, from 3 cm/μsec. to 0·1 cm/sec, and a 5-times expansion is possible by means of the X amplifier. A rise time of 0·15μsec is provided on the Y amplifier, but a high-train narrow-band condition is also incorporated. The accuracy of voltage measurement is ±1 per cent.

It is expected that the Remscope should greatly extend the range of measurements and observations possible without recourse to photographic recording. Deliveries are planned to begin in July, and further details may be obtained from Cawkell Research and Electronics Ltd.

Low-Frequency Generator

A LOW-FREQUENCY generator having a variety of uses has recently been introduced by Servo Consultants Ltd., 17, Woodfield Road, London, W.9. It is available in two forms, the Type G110 that has a frequency range of 100 to 0·001 cycles/sec and the Type G111, with a range of 10 to 0·0001 cycles/sec. The generator, with its variable-speed drive and ancillary equipment, is housed in a portable, aluminium alloy case measuring 18 × 18 × 10 in, on the front of which are the controls. It can be used to supply a slowly varying sinusoidal signal for testing all kinds of process controllers and servo mechanisms; its other uses are as a modulator, as a variable-speed precision drive and as a control system response recorder. A leaflet giving details is available from the manufacturers, at the address given.

MACHINE TOOL SELECTION IN THE MOTOR INDUSTRY

An Evaluation of the Factors Involved and Examples of Comparative Cost Studies

J. G. Smith, A.M.I.Prod.E.

MANUFACTURING methods employed within the motor industry include the use of standard general-purpose machines, special-purpose machines, and automation represented by groups of interlinked individual machines and transfer machines. When a manufacturing sequence is being planned for particular components, the choice of machines is sometimes fairly obvious. For instance, unless the required production volumes are high, small housings and covers are usually machined on simple, standard-type milling, drilling, and boring machines fitted with special tooling equipment. Often, however, the quantities required are such that alternative methods allow a choice between general-purpose machines and specialized machines, and between different specialized machines. When these alternatives exist the method selected may be determined largely by previous experience and practice, or it may be decided by the results of a detailed cost study.

Internal factors influencing choice of equipment

The economic effect of a particular method or machine will vary between individual firms, because of differences in organization and other factors. Even when components and quantities are similar and the firms operate under the same economic conditions, such variation is to be expected. The principal internal factors which influence the choice of methods, machines, and their operation may be considered as under:

1. Engineering
2. Labour relations
3. Costing
4. Purchasing.

The related functions of design, production, and plant engineering are of paramount importance. In particular, because the specific design of a part always limits manufacturing possibilities, co-operation between design and production engineering groups is vitally important. Effective co-operation can result in the ability to employ high-production machines and automation even when several different models are produced and the required volumes are relatively low. For example, the basic dimensions of some components, such as cylinder blocks and cylinder heads, can be made common for a range of engines so that a single transfer line can accommodate the entire model range of a particular component. Again, changes in the design of a part are sometimes essential to provide location surfaces, holes, and clamping pads, particularly when automatic processing is to be used. The additional cost of machining specific locations is usually more than offset by the simplification and reduced cost of work-holding equipment used for subsequent operations, by reduced handling times, and by a reduction in the scrap rate.

The importance of good labour relations in creating conditions in which labour can be used effectively, where men will accept the introduction of new machines and processes, and also redeployment, is critical. Paradoxically, however, an organization not able to use its labour to full effect may find it more profitable to introduce automation for some operations than another organization that uses labour more effectively. It is usually a saving in direct labour costs that provides economic justification for automation, and it becomes progressively more difficult to make appreciable savings in direct labour costs as labour is used more effectively.

A costing system providing a detailed analysis of all manufacturing costs, direct and indirect, is the necessary basis for accurate product costs. This, of course, requires effective work-measurement and work-standard functions. Cost studies undertaken to determine the economic effect of alternative methods and machines can be of value only when accurate figures are available for all the factors concerned.

In some cases the effective use of a machine or a process will be dependent upon the ability of purchase departments to obtain supplies of components with closely controlled physical characteristics; forgings, for example. Other machines may depend upon the supply of special cutting tools or other wearable items, possibly from an overseas source. Where it is proposed to install equipment depending for effective operation on specific physical characteristics in bought stock, or on other items not freely available, it is essential to establish the ability to obtain supplies before the equipment is purchased.

Cost studies

Cost studies may be undertaken to determine the economic effect of replacing existing machines by other machines, or to compare the effect of alternative methods and machines considered for a new project. Although these studies may be used to establish unit product costs, a direct comparison of unit costs does not necessarily provide evidence of economic justification for a method or a machine. Ultimately, economic justification must be expressed in terms of return on capital investment. The economic profitability of any capital expenditure is expressed by the financial return accruing from that expenditure. The financial return, considered in relation to the time required to recover the capital outlay, therefore, provides the basis for assessing economic justification. Cost studies of this description should provide figures showing:

(a) Recovery period
(b) Return on investment.

In studies where it is proposed to replace existing machines by different new machines, the recovery period is the estimated time required for the complete recovery of the total outlay by savings in operating costs. Where a study compares alternative machines, it is the estimated time required for complete recovery of the total additional outlay required for one machine against another by savings in operating costs resulting from the additional expenditure.

Where it is proposed to replace existing equipment by new machines, it is reasonable to deduct from the required capital outlay an amount equal to the estimated salvage value of the old equipment. Also, if the old equipment can be used on another project an amount equal to its assessed value can be deducted from the proposed outlay. The total cost savings before deductions for depreciation and

amortization are used in the calculation. Because the recovery period is the time required specifically for recovery of capital outlay, it follows that a true profit will not be obtained in any instance unless the equipment continues in operation beyond this period.

Where it is proposed to replace existing machines by different new machines, the return on investment shows the relationship between the total proposed capital expenditure and the additional operating profit expected to result from this expenditure. Where a study compares alternative machines considered for a new project, it shows the relationship between the difference in the total capital expenditure required for one machine against another and the additional operating profit expected to result from the additional expenditure.

It is convenient to express the return on investment as a percentage per annum. The return can be calculated on a yearly basis but, since the amount of capital tied up during the life of an asset is progressively recovered through depreciation and amortization, it is reasonable to determine the average return by a calculation using a figure equal to one-half of the total capital outlay. Usually, some proportion of the total capital outlay will be recovered through amortization over a shorter period than the life of the machines, so that the actual return on investment is more favourable than that obtained by this calculation. In calculating the return, depreciation and amortization are regarded as part of operating expense and deducted from operating cost savings. Where the anticipated life of an asset exceeds that of the particular part for which it is considered, it is assumed that the asset will operate under similar conditions throughout its life, so that calculations are based on average conditions.

Operating costs

In cost studies of this description it is usually assumed that use will be made of some existing facilities and that certain items of overhead expenses will be common for any method selected. When calculating operating costs, common items of overhead expense are therefore neglected and marginal factors only are considered. In particular, consideration must be given to the following items:

1. *Volume.* This is the number of units or components upon which the operating cost figures are based. Volume is normally expressed in terms of units per year and it is nearly always a critical factor in determining choice of equipment. Where automation is concerned it is the determining factor.

2. *Equipment.* For the purpose of calculating depreciation and amortization charges, it is necessary to distinguish between capital expenditure incurred for equipment that can be used only for producing a specific component, and capital expenditure incurred for equipment that can subsequently be adapted for other use. For instance, some machines are specialized to the extent that they can be used only for a particular component, while other machines can be adapted for operations on many different components by the use of special-purpose tooling. Often, also, specialized production machines can be used on other similar components, only certain elements of the machine being completely special.

Machines that can be adapted for other operations are normally depreciated according to their estimated life, while special purpose equipment is amortized according to the life of the component or model. It is convenient to distinguish the two categories, as follows:

(a) Machinery: the cost of a new machine, or a part of a machine, that can be adapted for other operations is assessed against this classification. With this cost is included the cost of freight, insurance, duty if applicable, and the estimated cost of installing the machine

(b) Special tools: the cost of all special purpose tools and other items designed for use on a specific part, and not adaptable for other use, is assessed against this classification. The cost of multiple-spindle drilling heads, fixtures, some machines and certain machine elements comes within this category.

3. *Associated expense.* In some cases the installation of new machines may involve the re-arrangement of existing machines and the provision of additional equipment such as hoists, swarf conveyors, or roller tracks. Items of this description are charged against operating costs. Where expense is incurred for a particular part it is amortized over the life of the part. Where assets that can be adapted for other purposes are concerned, they are depreciated according to their estimated life.

4. *Expense tools.* The cost of cutting tools and other consumption items can sometimes become a major part of operating costs. It is important, therefore, to assess these costs separately for each method or machine, since they may be determining factors. Previous experience will usually provide the basis for estimating tool costs, but in critical cases it may be necessary to carry out actual cutting tests.

It is sometimes possible to neglect the cost of cutting tools when comparing different machines, since it will be the same in each case. For instance, if transfer machines are being considered as an alternative to way-type machines, the consumption of such tools as milling cutters, drills, reamers, and taps will be the same, providing the same cutting speeds and feeds are used.

5. *Cost of labour.* It is necessary to consider the cost of labour under two categories as:

(a) Direct labour: this is assessed as the cost of labour directly applied to produce a given volume of parts. To obtain the total labour cost the labour rates must be adjusted to include the cost of insurance, pensions, welfare and similar charges.

(b) Indirect labour: with marginal studies it is usually only necessary to consider the cost of supervision and inspection. Often this cost can be neglected since it will be common.

6. *Power.* It is often difficult to assess power consumption with a close degree of accuracy. Generally, however, power consumption is not a determining factor and a sufficiently accurate approximation is obtained by assuming that the rated power of a machine is consumed during its operating cycle. A more critical analysis may be necessary where machines or processes consume large amounts of power.

7. *Maintenance.* The cost of maintenance may be appreciable in some cases and it is important to assess the cost of labour and material as closely as possible when making comparisons between machines. Where in-line transfer machines are compared with equivalent conventional machines the difference in maintenance costs is small and usually favours the transfer machines. These machines are less subject to abuse and small defects receive immediate attention.

8. *Miscellaneous.* Some cost items which are not usually critical, such as cutting oils, lubricating oils and protective clothing for operators can conveniently be grouped as a single cost.

9. *Floor area occupied.* There may be a considerable difference between the floor areas occupied by machines and operators for one method as against another. The areas occupied, therefore, are assessed in each case so that the difference can be included as a factor in the study.

10. *Other factors.* In some cases it may be necessary to consider other factors. For example, alternative methods may sometimes involve a difference in direct material costs or in transport charges. Also, in some cases, the cost of defective parts produced by one method as compared with another may be appreciable. Other comparisons may involve the relative cost of utilities such as gas, air and heat treatment. The extraction of dust or fumes may also be a factor.

Rotary table transfer machines

Rotary table transfer machines have been applied in the motor industry for many years. The advantage they offer is the ability to perform successive operations simultaneously on a number of components without intermediate work-handling; loading and unloading being carried out during the operational cycle. There is consequently a saving in direct labour cost and usually a saving in floor area occupied as against standard machines performing the same operations. Although these machines are tooled for special-purpose applications, they are flexible and can be re-tooled comparatively easily. They are to be regarded as specialized-production machines rather than special-purpose machines.

Where a component can be completely machined on a single rotary machine, or on several similar machines, the full potential saving in direct labour cost can be realized. Often, however, these machines are installed in progressive machining lines containing a variety of machines and the full potential saving is not realized. Progressive lines often operate inefficiently because one or more operations are out of balance with preceding or succeeding ones, and output and workload inequalities exist. The production rate of the slowest operation determines the line output, and the efficiency of the other operations is low. In such cases it is the practice to allow out-of-balance time for the faster operations to compensate for delays caused by the slower machines.

If production requirements are high a closer line balance may be achieved by duplicating the slower operations. Where this is not justified, it is sometimes possible to operate the slower machines for more hours than the rest of the line, either by some hours of overtime or by operating them on a second shift. By this procedure a bank of parts can be built up ahead of the slower machines. The possibilities in this direction are likely to be considerably restricted where large parts are involved.

Where labour can be used effectively and redeployment is possible, unbalanced conditions can be absorbed to some extent by assigning operators to other jobs along the line during the course of a shift, and even by transferring them to adjacent lines for some period of time. Under these circumstances it is possible to install rotary machines in relatively low-volume lines and still obtain a considerable advantage.

The following is an example of a cost study undertaken to determine the effect of replacing two existing standard machines by a rotary-table milling machine.

Existing method

The first operations on a casting requiring twelve machining operations consist of two milling operations and two drilling operations. These operations are performed on four standard machines operated by one man to give a production rate of ten pieces per hour, all his time being used productively. The two milling operations and a later boring operation determine the line output at ten per hour. The daily requirement is two-hundred pieces, necessitating double-shift working.

Proposed method

It is proposed to replace the two milling machines by a rotary-table milling machine that will perform both operations. Alternative fixtures will be interspaced on the table and with the constant attention of one man the machine will produce at the rate of twenty-four pieces per hour, so that the direct labour cost of the operations will be 2·5 minutes, compared with 4·0 minutes by the existing method. This machine will produce the required quantity in one shift but because of the relative bulk of the component and the fact that there is another controlling operation, boring, down the line, it is not considered an advantage to do this. By operating on a two-shift basis the speeding up of the initial controlling operations will allow redeployment of labour which will eliminate 2·8 minutes of out-of-balance time from other operations, so that a total saving of 4·3 minutes of direct labour per piece will be obtained.

The time 4·0 minutes for the existing milling operations is the actual direct labour cost and not an estimate. The times for the revised milling operation and the saving in out-of-balance time are estimates. The saving of 2·8 minutes is obtained by improving the workload balance for the other operations down the line.

Study

In this study an aggregate direct labour rate of 6·75s. per hour is used for day-shift work and 8·5s. per hour is used for night-shift work. Bonus rates are not considered. The cost of power is based on a rate of 1d. per h.p. per hour. Cost items which are the same for each method, or where the difference is negligible, are ignored.

Machinery is depreciated over twelve years. Existing special tools are amortized over six years, and the proposed special tools over four years, which would be the remaining life of the component after the introduction of the new equipment. Figures for power, depreciation and amortization relate only to the equipment directly concerned in the study.

The following results are obtained:

Capital cost of proposed method:

Machinery = £5,460 (British)
Special tools = £1,200
Total = £6,660

Annual volume required is 48,000.

Item	Annual operating costs		Increase	Decrease
	Existing method	*Proposed method*		
Direct labour	£5,490	£4,178	—	£1,312
Power	208	140	—	68
Miscellaneous	182	158	—	24
Depreciation	458	455	—	3
Special tools amortization	80	300	£220	—
Total	£6,418	£5,231	—	£1,187

The saving in operating costs before depreciation and amortization is £1,404 and an allowance of £3,000 is made for the released machines so that:

$$\text{Recovery period} = \frac{(6{,}600-3{,}000)\times 12}{1{,}404} = 31{\cdot}2 \text{ months}$$

$$\text{Return on investment} = \frac{1{,}187\times 100}{(6{,}660\div 2)} = 35 \text{ per cent}$$

There will be a saving in floor area of approximately 100 ft^2 if the new machine is installed.

In this case the return on the capital outlay and the recovery period are good and the project is sound. The results are due to the saving in direct labour costs and the allowance made for the released machines. Without the allowance, the recovery period would be 56·9 months but this would not invalidate the project because:

1. The additional outlay on special tools is easily recovered within the life of the part.
2. The machine is readily adaptable for other production and is not likely to become obsolete. The return on investment figure is an average figure based on the estimated life of the asset and it can be assumed that similar conditions will apply during that life. The operating conditions are average, the machine would be used for similar operations throughout

its life, and it could be expected to continue to show a similar advantage over standard machines.

Taxation and investment allowances have not been considered in the above study. The application of an investment allowance will make any project of this description more attractive since, in effect, the recovery period will be reduced and the return on the investment increased.

In-line transfer machines

Because of the relatively high capital cost involved and their limited flexibility, in-line transfer machines are normally considered only where quantity requirements are high and major changes in component design are not likely to occur. Usually, a component required in quantities large enough to warrant consideration of these machines will otherwise be made on standard machines equipped with special tooling, and on way-type or other special machines, possibly provided with automatic loading devices. Almost invariably at present, the cost of an in-line machine is greater than the cost of the alternative conventional equipment.

In-line machines are generally constructed from standard machine units such as centre beds, bed extensions, columns and work heads. The cost of these, and of the special tooling used with the work heads, is approximately the same as for the equivalent conventional equipment. The cost of special work heads for milling and other operations can usually be balanced against the cost of equipment otherwise used for the same operations. The increase in cost is mainly due to the cost of the transfer equipment, the more complex electrical control gear, and the additional centre beds, fixtures and other items required for the additional working stations necessary because the number of work heads that can operate at an individual station is limited. The increase in cost is not constant and it can vary considerably according to the application. Generally, the cost of an in-line transfer machine is between 10 and 30 per cent more than the cost of conventional machines for the same operation.

It is largely a saving in direct labour costs which must pay for the increased capital cost if in-line machines are to be justified economically. Because handling time between operations is eliminated and all operations are performed simultaneously, in-line machines can be highly productive. Where they are operated at full capacity the saving in direct labour alone will easily justify the increased capital cost. Often in Britain, however, volume requirements are not high enough to allow the machines to be operated at full capacity, and the return on the additional capital expenditure is then likely to be small.

The following study compares alternative methods for the manufacture of a large transmission housing; one method uses conventional machines and the other method transfer machines in conjunction with conventional machines. British equipment is considered in each case.

Conventional method

This uses seventeen machines, consisting of three special, heavy-duty milling machines and fourteen way-type boring, drilling, reaming, and tapping machines. Two milling machines and two way-type machines being common for each method. The daily requirement is 200 and the estimated production rate, determined by the milling operations, is 12·5 per hour and necessitates double-shift working. At this production rate, seven men are required for each shift. The direct labour cost, including out-of-balance time, is therefore 33·6 minutes per part.

Transfer method

This uses three transfer machines with four conventional machines. Two milling machines and one way-type machine perform initial operations, and one way-type machine performs certain boring operations between the first and second transfer machines. The transfer machines have a total of twenty-four working stations. Separate transfer machines are considered because the volume does not warrant the cost of a fully automated line. Platens are not used; the parts slide through the machines on a machined location surface. This method requires four men for each shift. The direct labour cost, including out-of-balance time, is therefore 19·2 minutes per part.

Study

Labour and power rates are as quoted previously. Machinery is depreciated over twelve years and special tools are amortized over six years. Capital costs include built-in swarf conveyors for the transfer method and a gravity-type roller-conveyor system for the conventional method. The annual volume is 48,000.

The following results are obtained:

Item	Capital cost		Increase	Decrease
	Conventional method	*Transfer method*		
Machinery	£131,400	£158,520	£27,120	—
Special tools	66,300	75,090	8,790	—
Total	£197,700	£233,610	£35,910	—

Item	Annual operating costs		Increase	Decrease
	Conventional method	*Transfer method*		
Direct labour	£10,248	£5,856	—	£4,392
Indirect labour	400	160	—	240
Power	2,200	2,540	£340	—
Maintenance	6,355	5,360	—	995
Miscellaneous	460	297	—	163
Scrap	382	277	—	105
Depreciation	10,950	13,210	2,260	—
Special tools amortization	11,050	12,515	1,465	—
Total	£42,045	£40,215	—	£1,830

The saving in operating costs before depreciation and amortization is £5,555, so that:

$$\text{Recovery period} = \frac{35{,}910 \times 12}{5{,}555} = 77{\cdot}5 \text{ months}$$

$$\text{Return on investment} = \frac{1{,}830 \times 100}{(35{,}910 \div 2)} = 10 \text{ per cent}$$

There will be a saving in floor area of approximately 150 ft^2 if the transfer line is installed.

For the volume required, the return on the additional capital is not good, although most of the additional outlay will be recovered within the life of the component. Volume is the critical factor; a 25 per cent increase (a) or decrease (b) in volume would give the following figures:

(a) Recovery period 62·5 months
Return on investment 17 per cent
(b) Recovery period 105·5 months
Return on investment 2 per cent

In the circumstances considered, the output of progressive lines is generally controlled by milling and boring operations; other machines usually have capacity well in excess of the controlling machines. On the transfer line, output is controlled by the two milling machines and the way-type boring machine. The same machines also control output on the conventional line, and if they are duplicated either

line will produce at the rate of twenty-five parts per hour to provide a volume of 400 per day.

Should this increased volume be required, an improved line balance would be obtained on the transfer line by moving the intermediate boring operation to the end of the line. The line would contain ten machines and seven men would be required for each shift so that the direct labour cost would be 16·8 minutes per part. An improved line balance would also be obtained for the conventional line. The line would contain twenty machines and twelve men would be required for each shift so that the direct labour cost would be 28·8 minutes per part.

The capital differential would remain the same and the results of the study would be:

Recovery period 47·2 months
Return on investment 30 per cent

For the increased volume it would be reasonable to link the transfer machines to form a single line because the increase in capital expenditure would be balanced by a reduction in direct labour and the results would still be attractive.

Although the results of the study based on the original volume are not attractive there are still reasons for selecting the transfer line for this volume. The housing is large and heavy and it is probable that a basically similar part will be required during the life of the machine, allowing continued use of some proportion of the special tooling. In view of this, and since there is some return on the investment, the following factors in favour of the transfer method warrant serious consideration:

1. Less labour is required and because the need for physical effort is reduced the problem of selecting labour capable of handling heavy components will be avoided.
2. Transfer machines can be expected to operate at a higher rate of efficiency since they are less directly controlled by labour and, similarly, handling operations are systematized.
3. Quality should be improved, because transfer machines will produce more consistently and there is reduced possibility of damage during handling.
4. Increased safety in operation
5. There will be greater saving if labour costs continue to rise
6. There will be greater saving if increased volumes are required.

In this, as in other similar cases, the acceptable return on investment and the recovery period must be finally decided by management according to the general level of efficiency of the organization, the availability of capital and the level of industrial activity prevailing.

Conclusions

Volumes, the cost of labour, the degree to which labour is used effectively, and relative capital costs, are the factors which determine the extent to which specialized machines and automation can be applied. Over recent years volumes have been increasing and labour costs rising and it is reasonable to suppose that these trends will continue. The ability to apply transfer machines and other automatic processing equipment will therefore be extended.

The risk of early obsolescence inherent in planning a long-term investment in automated equipment can be diminished to some extent by increased flexibility and versatility in equipment allowing greater freedom and economy in re-tooling. Standardization and the extension of the building-block principle should improve equipment in this respect and should also lower costs. Any reduction in costs, as against standard machine costs, will reduce the capital differential and obviously make some degree of automation attractive for marginal-volume production. There is considerable scope for the development of automatic loading devices and transfer units for use on conventional machine lines for smaller components and lower volumes.

Russian Publication

BY ARRANGEMENT with the Department of Scientific and Industrial Research, The Iron and Steel Institute is undertaking the monthly publication of an English translation of *Stal*, the important Russian periodical on iron and steel technology. This service starts with the January 1959 issue, which should shortly be available in its translated form. *Stal* contains details of the more significant developments in this particular sphere, and the Institute feels that it should prove of considerable interest to the industry in this country. An order form and details of the subscription rates may be obtained from the Secretary, The Iron and Steel Institute, whose address is 4 Grosvenor Gardens, London, S.W.1.

Manufacturing Instructions

IT IS CLAIMED that a new method of instructing workers, introduced in the U.S.A. by the Dictaphone Corporation, is capable of increasing production by upward of 20 per cent. The new system has been given the name of Audio Instructed Manufacturing Operation, abbreviated to AIMO, and it can be used for any type of operation in which the operator normally follows a blueprint or written instructions. The AIMO system makes use of a special form of tape recorder, to which information has been dictated by an instructor working from the appropriate drawings.

When the instructions are played back by the machine, they are picked up by a small receiver, carried on the belt of the operator, and communicated to a listening device on his ear. To start the machine, the operator presses with his foot on a hydraulic tube on the floor; the machine then transmits one section of the instructions and pauses to enable them to be carried out. When the operations have been completed, a further pressure on the hydraulic tube causes the next block of instructions to be transmitted. If the instructions are not understood, or the operator wishes to check a detail, the recording tape may be back-spaced by pressure on another control tube.

The manufacturers believe that the AIMO scheme could prove particularly valuable in the electrical industry, where relatively untrained workers are required to follow intricate wiring diagrams. Because of the sub-division of the instructions into short blocks, the operator has no difficulty in memorizing them, and there is, of course, the ability to have them repeated. An investigation of the system is at present being carried out by the Dictaphone Corporation's British associated company, the Dictaphone Co. Ltd., of Acton, London, with a view to manufacture in this country.

Curing Injector Troubles

CONSIDERABLE bother has been experienced in diesel powered trucks in the U.S.A. because of a tendency of certain fuels to cause injector sticking and filter clogging. According to extensive field tests, it would appear that these problems have been largely solved by an additive produced by E. I. du Pont de Nemours and Co. Inc., of Delaware. This substance, which is known as FOA-2, has been added to the fuel in varying proportions up to $1\frac{1}{2}$ lb per 1,000 U.S. gallons, and even half that amount has proved very effective. It is also said to have the advantage of increasing injector life.

CURRENT PATENTS

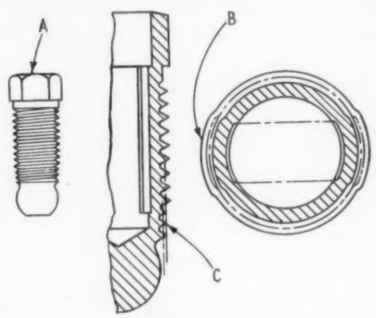
A REVIEW OF RECENT AUTOMOBILE SPECIFICATIONS

Self-locking adjuster screw

An earlier specification No. 749310, reviewed in the January 1957 issue of *Automobile Engineer*, disclosed a self-locking screw that enabled valve clearance adjustments to be made with a single wrench and a feeler gauge. A typical screw, as shown at A, has a ball- or cup-end and, at the other extremity a head to receive a wrench. It is drilled axially from the head end, and externally is formed with a standard screw thread. A special tool is forced into the drilling to expand the threaded wall at two or three points of the circumference.

It has been found that the locking action provided was scarcely adequate to withstand the forces encountered in a valve gear. This is because the pitch line of the screw thread, in longitudinal section, defines a cone and, in transverse section an elliptical or other smooth, non-circular curve. Thus the thread makes substantially point contact rather than area contact.

The present invention overcomes this



No. 801265

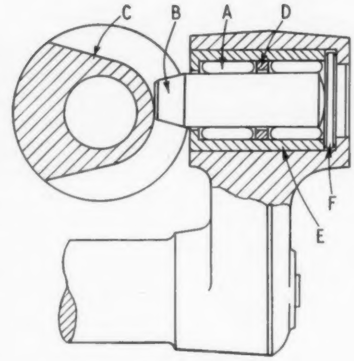
inadequacy. A parallel tool is used to produce either two or three locking lobes B of substantial area. Depth of insertion is limited to leave the first few convolutions of the thread undistorted, as shown at C, to ensure easy initial engagement.

As illustrated, the screw is intended for the rocker lever of an overhead valve gear. A solid-headed tappet screw, open at the lower end, is formed in similar manner. *Patent No.* 801265. *National Machine Products Co.* (*U.S.A.*).

Cam and peg steering gear

In gears of this type it has become usual practice to mount the peg for rotation in an anti-friction bearing in the rocker arm. Commonly these bearings are of the needle roller type, the rollers having a high length : diameter ratio so as to afford maximum support to the peg. There is a tendency for such long rollers to skew-wind in operation and consequently to set up increased friction. This potential defect is avoided by employing two or more independent sets of relatively short rollers to support the peg. The ends of rollers in adjacent sets are separated by a spacer ring.

Examples illustrated show two sets of short rollers A, which jointly extend over the major portion of the length of peg B. The construction permits the free withdrawal of the peg axially in the direction of the cam C. Spacer ring D is a push fit



No. 800298

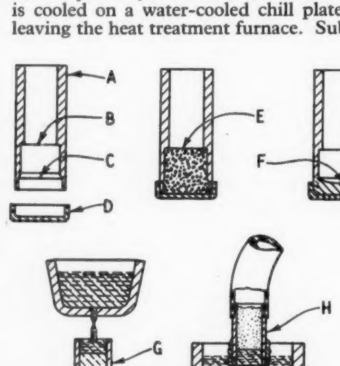
in the outer race E and internally clears the peg B. Rollers may have part-spherical ends to make contact with the spacer ring, the end flange of the race and the inserted, hardened steel pad F.

In one of three modified designs, the rollers run directly in a boring in the rocker arm and are retained by a screwed-in hardened steel plug. *Patent No.* 800298. *Cam Gears Ltd.*

Composite valve tappets

Cost is reduced, it is claimed, by this composite construction of valve tappets. The main body portion is of relatively inexpensive metal and only the foot part is of cast, hard, wear-resistant material metallurgically bonded thereto. A tubular body A has a three-diameter bore with a normal shoulder at B and a conical shoulder at C. Over the thin-walled lower end is lightly fitted a pressed-steel cap D, and both the cap and the bore of the tappet, above shoulder B, are coated with a stop-off material to prevent adherence of molten metal. Suitable coating materials are an alumina-base refractory or an aluminium paint.

A measured quantity of cast iron shot E is placed in the closed end of the body and is then fused to bond metallurgically to the body metal, as at F. The cast iron foot is cooled on a water-cooled chill plate on leaving the heat treatment furnace. Subsequently, the cap is stripped off and the tappet machined, as required, both internally and externally.

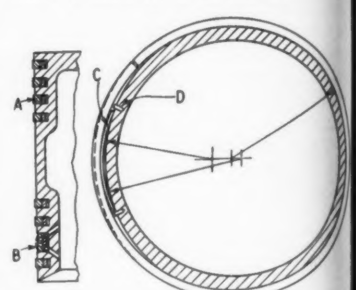


No. 801042

Other methods are outlined in the specification. At G, the tubular body is partially filled with a carbon plug and seated on a carbon block. This assembly is heated to about 1,500 deg F and a measured amount of molten metal is delivered from a crucible to form the foot. At H, the body is plugged with a porous sand core, coated at the lower end with a refractory material, and dipped into molten metal in a crucible. Vacuum is applied by way of a flexible conduit to draw the metal into the body. *Patent No.* 801042. *General Motors Corporation* (*U.S.A.*).

Anti-slap piston ring assembly

A relatively short, solid-skirted piston, such as is used in racing car and aircraft engines, is usually designed with a generous clearance to preclude the possibility of seizure, and tends to the noisy in operation, due to piston slap. Since such a piston can



No. 801199

tilt in the bore, thereby carrying the rings out of alignment, oil consumption is liable to be unduly high and also difficult to control. These disadvantages, it is suggested, can be obviated or mitigated by this invention.

The piston is grooved to take a plurality of normal rings A arranged in upper and lower groups. In the lower group one or more oil-control rings B of any suitable design will be included. Between each ring A and the bottom of its respective groove is inserted a resilient ring segment C having an outer radius less than the outer radius of the piston. Its two ends contact the bottom of the groove and it is compressible by flattening towards the groove bottom. To accommodate the segment C the groove is relieved over about 90 deg by eccentric turning or by arcuate recessing on one side of the piston. All the reliefs are longitudinally aligned.

In the example illustrated, the segment C spans approximately 60 deg but any suitable span may be adopted, though normally this would not exceed 90 deg. Pegs D in the groove relief prevent circumferential wandering of the segment. The pressure exerted by the segment needs only to be light and does not add substantially to piston friction. Gas sealing is improved as the rings are maintained square with the bore and the oil control system can work effectively. *Patent No.* 801199. *Cross Manufacturing Co.* (1938) *Ltd.*

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